CONSULTANT REPORT

PIER
Public Interest Energy Research
CALIFORNIA ENERGY COMMISSION

Buildings End-Use
Energy Efficiency

A TOOL FOR THE COMPREHENSIVE ENERGY ANALYSIS OF LOW-RISE RESIDENTIAL BUILDINGS

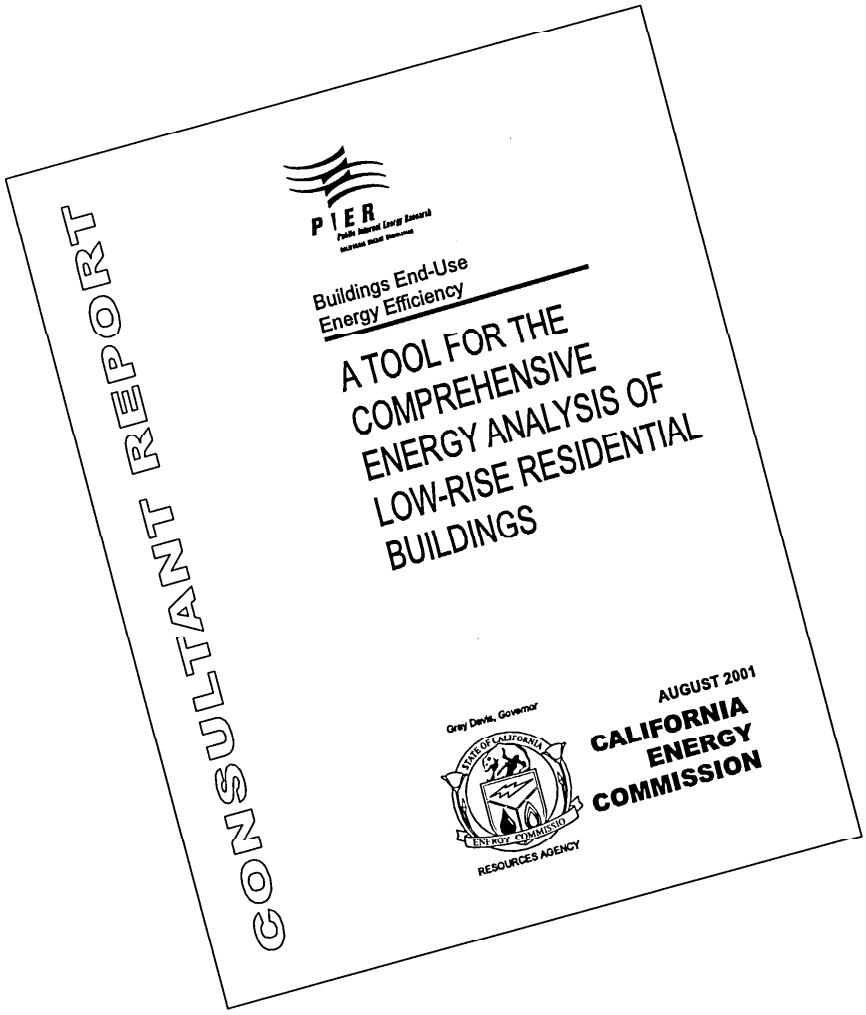
Gray Davis, *Governor*

STATE OF CALIFORNIA
ENERGY COMMISSION
RESOURCES AGENCY

AUGUST 2001

CALIFORNIA ENERGY COMMISSION

P600-01-015



CALIFORNIA ENERGY COMMISSION

Prepared for:

CALIFORNIA ENERGY COMMISSION

Martha Brooke, *Contract Manager*

XXXXXXXXXXXXXXXXXXX

Prepared by:

Charles Eley, Principal Investigator

ELEY ASSOCIATES

Nancy Jenkins, *Team Lead*

BUILDINGS END-USE ENERGY EFFICIENCY RESEARCH

San Francisco, CA

Contract No. 500-98-025

Contract Amount: $216,190

Legal Notice

Acknowledgements

The authors greatly appreciate the research support from the California Energy Commission, and the useful comments and feedback from project managers John Eash and Martha Brooke.

The project team at Eley Associates included Charles Eley as project management, research lead, and software mockup; Tianzhen Hong for programming, validation, online help system, and user manual development; Erik Kolderup for leading the background research task; Tanmay Tathagat for programming support; and Anamika Prasad for in-house software testing.

Catherine Cooper, Catherine Cooper Market Research, performed market research, which included conducting focus groups and interviews with design professionals and builders.

Table of Contents

Section **Page**

Preface ..... **vi**

Executive Summary **1**

Abstract **3**

1.0 Introduction **4**

1.1. Background 4
1.2. Objectives 5

2.0 Project Approach **6**

2.1. Software Features 7
2.1.1. Extensibility 7
2.1.2. Homeowner Wizard 7
2.1.3. Calibration to Utility Billing History 7
2.1.4. Utility Rates 8
2.1.5. Auto-Build 9
2.1.6. Polygon Extrusion 11
2.1.7. Attics Crawlspaces and other Unconditioned Spaces 11
2.1.8. Library Editors 11
2.1.9. Information Flow 13
2.1.10. Graphic Display of Building Model 14
2.1.11. Graphic Display of Simulation Results 15
2.1.12. HVAC Ducts 15
2.1.13. Lights and Appliances 16
2.1.14. Interfaces to Other Software Applications 17

3.0 Project Tasks **18**

3.1. Task 1 - User Groups 18
3.2. Task 2 - Background Research 19
3.3. Task 3 - Software Specification 19
3.4. Task 4 - Alpha Coding 19
3.5. Task 5 - Alpha Testing and Review 20
3.6. Task 6 - User Documents and Help System 20
3.7. Task 7 - Beta Coding 20
3.8. Task 8 - Validation 20
3.9. Task 9 - Beta Testing and Revisions 20

4.0 Project Outcomes **21**

5.0 Conclusions and Recommendations **22**

5.1. Conclusions 22
5.2. Benefits to California 22
5.3. Recommendations 22

6.0 References **23**

Appendices

Appendix I	Software Specification
Appendix II	User Manual
Appendix III	Background Research
Appendix IV	Validation Report
Appendix V	A Qualitative Research Report on Homeowners' Reactions to the Home Energy Advisor
Appendix VI	Residential Building Professionals' Reactions to the Home Energy Advisor
Appendix VII	Product Readiness Plan

List of Figures

Figure	Page
Figure 1: Software Architecture	6
Figure 2: Software Components	6
Figure 3: Utility Rate Editor	8
Figure 4: The General Folder	9
Figure 5: The Shape Folder	9
Figure 6: Rules to Auto-Build a House	10
Figure 7: Polygon Extrusion Method of Creating Building Models	11
Figure 8: Information Flow	13
Figure 9: Three Dimensional View of the Model	14
Figure 10: Graphic Results - Electricity End Uses	15
Figure 11: Lights and Appliances	16
Figure 12: Lights Categories	16
Figure 13: Properties of Lights and Appliances	17

Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial / Agricultural / Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research.

What follows is the final report for the A Tool for the Comprehensive Energy Analysis of Low-Rise Residential Buildings contract, contract number 500-98-025, conducted by the Eley Associates. The report is entitled A Tool for the Comprehensive Energy Analysis of Low-Rise Residential Buildings. This project contributes to the Buildings End-Use Energy Efficiency program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

Executive Summary

This project developed a Windows-based design and analysis tool for residential buildings that uses DOE-2.1E as the calculation engine. The tool is simple enough for homeowners to use to evaluate proposals from energy service providers, while at the same time offering the power needed by design professionals and product and equipment manufacturers. It has the capability to model all aspects of residential energy use, including lighting (both interior and exterior), major appliances, miscellaneous equipment, air conditioning and heating equipment, and domestic hot water. Interactions between these components are an integral part of the model.

The project advances science and technology in the area of residential energy end-use. It accurately accounts for the interactions between building systems, provides a valuable tool to designers and product developers, and is easy enough for homeowners to use. It has features that can be used to evaluate complex utility rates that have time-of-use charges, demand charges, ratchets and other complex features.

We developed the tool for a wide audience. It enables homeowners to understand their energy use patterns and to be better informed in choosing an energy service provider in the unregulated marketplace. The tool allows architects, building designers, contractors, and homebuilders to evaluate design and/or equipment alternatives and make better decisions about what design strategies to employ or which equipment to specify. Product manufacturers can use the tool to develop and evaluate new equipment and products, especially when there are interactions between building processes and systems.

The project enables the unregulated market for electricity to function at a more optimum level. One of the key requirements for a well-functioning market is the free flow of information, especially pricing information. With a deregulated market, proposals from energy service providers may become quite complex, with time-of-use charges, demand charges, ratchets, and perhaps real-time pricing. Without tools like the one developed in this project, it would be very difficult for ratepayers to evaluate the differences between the myriad of proposals and offerings from energy service companies.

Objectives

Project objectives were to:

- Develop a Windows-based design and analysis tool that uses the DOE-2.1E energy simulation engine. The tool needed to be simple enough for homeowners to use, while at the same time offering the power needed by design professionals and product/equipment manufacturers.
- Produce complete documentation for the tool, including online help system, tutorial, user manual, and validation report.

Outcomes

This project achieved its objectives:

- A comprehensive residential energy analysis tool that performs a detailed hourly simulation of energy use in houses was produced in both a professional and home owner version that.
- Tool documentation including the online help system, tutorial, and user manual

Conclusions

- During the project we learned that it is very difficult to target a residential energy analysis tool to homeowners.
- The tool was better received by design and construction professionals, but we were unable to address one of the main issues that they raised, which was to make the tool work for energy code compliance.

Benefits to California

- Architects and engineers can use the tool in early design phase of residential houses to incorporate cost effective energy efficiency equipment and systems.
- Homeowners to evaluate various utility offers and energy efficiency measures when their houses are to be improved to reduce energy use can use the tool.
- The tool can be used as an education tool for students to understand energy efficiency of buildings and environment.

Recommendations

The following steps need to be accomplished:

We recommend that the software be modified to work as a code compliance tool. This would address a need identified by design professionals and contractors during our interviews.

There are also some technical areas that need additional attention. These include air distribution systems, combined hydronic space and water heating systems. The DOE-2 calculation engine is inadequate in modeling these systems. Calculation procedures are contained in the Residential ACM Approval Manual should be considered to supplement the DOE-2 algorithms.

The homeowners' version of the software was developed in response to focus group comments and substantial changes were made. Additional focus groups or market studies would enable us to verify that the changes address the issues that were raised in the initial focus groups.

Abstract

This project produced a Windows-based design and analysis tool for residential buildings that uses DOE-2.1E as the calculation engine. The tool is simple enough for homeowners to use in evaluating proposals from energy service providers, while at the same time offering the power needed by design professionals and product/equipment manufacturers. The tool has the capability to model all aspects of residential energy use, including lighting (both interior and exterior), major appliances, miscellaneous equipment, air conditioning and heating equipment, and domestic hot water. Interactions between these components are an integral part of the model.

We built the tool on two significant existing technologies. The first is the DOE-2.1E calculation engine. Developed in the early 1980s, DOE-2 has the capability to model all aspects of residential energy use, including lighting (both interior and exterior), major appliances, miscellaneous equipment, air conditioning and heating equipment, and domestic hot water. DOE-2 has become the most popular building energy analysis tool in the United States. The second foundation of the tool is the object-oriented software component technology used in a set of foundation classes developed by Eley Associates. The foundation classes exist as a separate software component and provide functionality to the interface including file input/output, graphic services, model construction, and component editing capabilities. The foundation classes technology is being employed in the latest versions of VisualDOE. The technical objective of this project was to leverage these existing software technologies to produce a tool that is useful to a wide sector of the residential building community.

1.0 Introduction

This project developed a Windows-based design and analysis tool for residential buildings that uses DOE-2.1E as the calculation engine. The tool is simple enough for homeowners to use to evaluate proposals from energy service providers, while at the same time offering the power needed by design professionals and product and equipment manufacturers. It has the capability to model all aspects of residential energy use, including lighting (both interior and exterior), major appliances, miscellaneous equipment, air conditioning and heating equipment, and domestic hot water. Interactions between these components are an integral part of the model.

The project advances science and technology in the area of residential energy end-use. It accurately accounts for the interactions between building systems, provides a valuable tool to designers and product developers, and is easy enough for homeowners to use. It has features that can be used to evaluate complex utility rates that have time-of-use charges, demand charges, ratchets and other complex features.

The tool is developed for a wide audience. It enables homeowners to understand their energy use patterns and to be better informed in choosing an energy service provider in the unregulated marketplace. The tool allows architects, building designers, contractors, and homebuilders to evaluate design and/or equipment alternatives and make better decisions about what design strategies to employ or which equipment to specify. Product manufacturers are able to use the tool to develop and evaluate new equipment and products, especially when there are interactions between building processes and systems.

The project enables the unregulated market for electricity to function at a more optimum level. One of the key requirements for a well-functioning market is the free flow of information, especially pricing information. With a deregulated market, proposals from energy service providers may become quite complex, with time-of-use charges, demand charges, ratchets, and perhaps real-time pricing. Without tools like the one developed in this project, it would be very difficult for ratepayers to evaluate the differences between the myriad of proposals and offerings from energy service companies.

1.1. Background

Easy-to-use tools did not previously exist for the comprehensive design, analysis, and evaluation of low-rise residential buildings. Tools like DOE-2, which have the capability of doing a comprehensive energy analysis, exist in the research community, but the time required and the expertise needed to use the tools are serious deterrents that all but eliminate their use by homeowners or mainstream practitioners. Others, such as CALRES and MICROPAS, are widely used for residential code compliance, but these tools only perform load calculations, are limited to just a few thermal zones, and lack equipment models to accurately simulate air conditioning and heating equipment. Furthermore, scheduling capabilities are limited, requiring that weekly and seasonal variations in use patterns be ignored.

1.2. Objectives

Project objectives were to:

- Develop a Windows-based design and analysis tool that uses the DOE-2.1E energy simulation engine. The tool needed to be simple enough for homeowners to use, while at the same time offering the power needed by design professionals and product/equipment manufacturers.
- Produce complete documentation for the tool, including online help system, tutorial, user manual, and validation report.

2.0 Project Approach

We based the tool on a three-tier architecture (Figure 1). The user interface tier is at the top level. This is the portion of the program exposed to the user. The interface includes the graphics and controls for defining the residential building and identifying options for evaluation. The interface uses the resources of the foundations classes (FC) tier. The FC tier is a collection of classes that can be instantiated to provide functionality to the interface. The FC tier exists as separate and distinct software components (Figure 2) and provides an interface to the calculation engine (DOE-2.1E), which is at the bottom tier of the software architecture. The calculation engine performs most of the energy calculations and produces some of the reports. The three-tier arrangement makes it more feasible to substitute alternative calculation engines, since it is necessary only to make modifications to one of the classes.

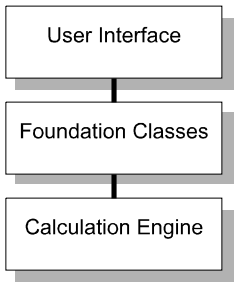


Figure 1: Software Architecture

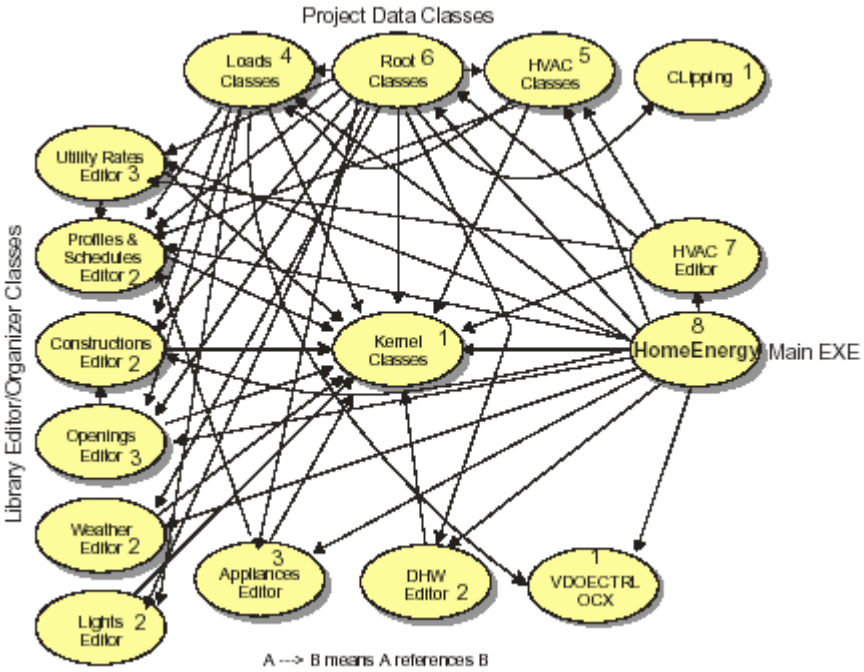


Figure 2: Software Components

The foundation classes and calculation engine technologies are mature. DOE-2 has been in existence since the early 1980s. The foundation classes technology has been under development since 1998 by Eley Associates. This technology is being employed in the latest version of

VisualDOE and in a special version of VisualDOE that is used as part of the PG&E CoolTools project. They are also used with CodeComp, a compliance tool for the state of Oregon. The technical objective of this project was to leverage these existing software technologies to produce a tool that will be useful to a wide sector of the residential building community.

The foundation classes and calculation engine software tiers required only minor modifications and enhancements. This project focused on the user interface and implemented some features that made the program especially powerful and useful to the wide audience.

2.1. Software Features

2.1.1. Extensibility

We designed the program to be extensible. Extensible means that the program can easily be used by a neophyte, but also be valuable to the expert. In order to achieve this goal, the program has to be fundamentally useful to the expert, with shortcuts provided for the neophyte. Wizards and other program features provide these shortcuts. Fundamentally, the calculation engine needs detailed information on the conditioned spaces in the house, the surfaces that surround the conditioned spaces, openings such as windows and doors that penetrate the surfaces, relationships between the spaces and the heating and cooling equipment, performance data about the heating and cooling equipment, and a myriad of other details. The expert needs access to this data, but the neophyte would simply be overwhelmed.

2.1.2. Homeowner Wizard

To enable the program to be used by a homeowner wanting to evaluate proposals from energy service providers, the project developed a special wizard. The wizard essentially bypasses the normal user interface and requests data from the homeowner in a logical sequence. The information requested includes: floor area, number of stories, construction date, heating system type (chosen from a list), cooling system type (chosen from a list), water heater type (chosen from a list), and setting (chosen from a list). The user's choices for setting are new subdivision, urban neighborhood with large trees, etc. Optional information includes type of windows, ceiling insulation, wall insulation, etc. With this information, the wizard constructs a model of the house, which can be viewed in graphic form.

2.1.3. Calibration to Utility Billing History

For existing homes, users have records of the electricity and gas use from past years. A form is available so that they can enter this data and calibrate the model to this data. The program then scales the base case simulation results to match the billing history. This is a valuable feature when evaluating proposals from energy service providers. The program also enables users to compare the unmodified base case simulation results to the billing history and to determine how the base case model might be modified to produce a better fit.

2.1.4. Utility Rates

The program has a library of utility rates that the user can choose from. The library includes the standard rates from the major utilities and energy service providers. When a user wants to evaluate a rate that is already in the library, it is a simple matter of selecting the rate from a list. If the rate is not in the library, it can be added through a utility rates editor (Figure 3). The utility rate editor has a small footprint and is freely available so that energy service providers and others can create files representing their rates.

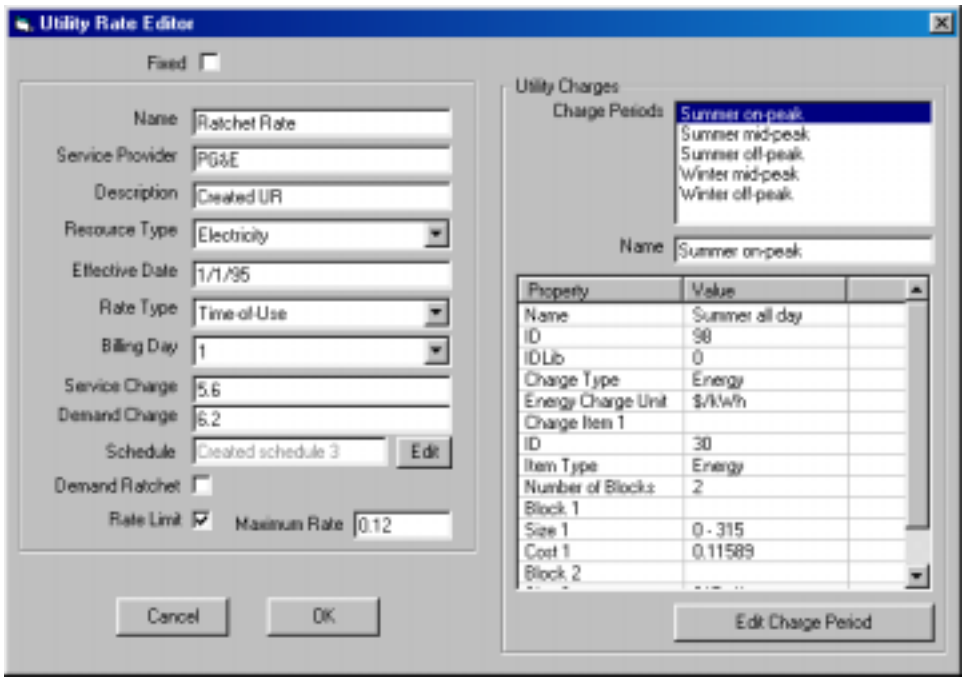


Figure 3: Utility Rate Editor

2.1.5. Auto-Build

The first step in making an energy simulation is to create the house model. To create a new house, the user first enters data in the General and Shape folders (Figure 4 and Figure 5) and clicks the Auto-Build button on the Shape Folder to create an energy model of the house. Figure 6 illustrates rules used in auto-creating a house shape. After a house has been auto-built, the user can modify data in other folders without clicking the Auto-Build button again.

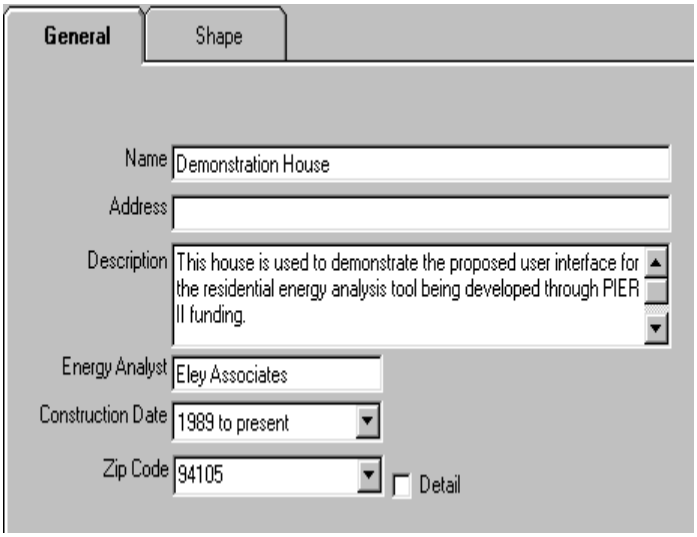
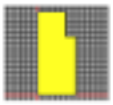
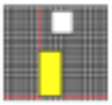
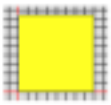
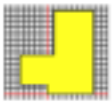
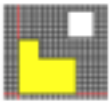
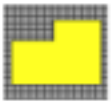
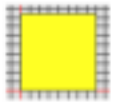


Figure 4: The General Folder

Figure 5: The Shape Folder

Rules used in auto building a house

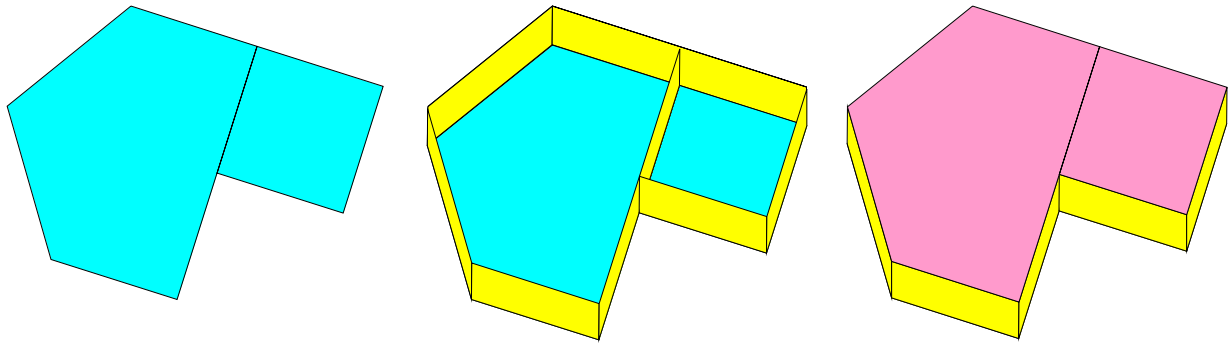
Style	Area (ft2)	Floor	Lot Width	Cars	Garage: Front	Left	Back	Right	Detached	None
Trad.	0-1300	1	40	1		N.A.		N.A.		
		2	40	1						
		3	30	1						
	1301-3000	1	50	2						
		2	40	2						
		3	40	2						
	3001-5000	1	60	2						
		2	50	2						
		3	40	2						
	> 5000	1	70	3						
		2	60	3						
		3	50	3						
					W=LW-16 D=A/(W*F)		W=LW-17 D=A/(W*F)			
Ranch	0-1300	1	60	1						
		2	50	1						
		3	40	1						
	1301-3000	1	70	2						
		2	60	2						
		3	50	2						
	3001-5000	1	80	2						
		2	70	2						
		3	60	2						
	> 5000	1	90	3						
		2	80	3						
		3	70	3						
					"L" shape only if A/(W*F)≥LW-10					
Townhouse Duplex and Apartment	0-1300	1	22	0	☐Party Wall Left ☐Party Wall Right ☐Top Floor ☐Bottom Floor					
		2	20	0						
		3	18	0						
	1301-3000	1	28	0						
		2	24	0						
		3	20	0						
	3001-5000	1	34	0						
		2	30	0						
		3	26	0						
	> 5000	1	40	0						
		2	36	0						
		3	32	0						

Where, A is the total floor area, W is the width of the house, LW is the lot width, D is the depth of the house, and F is the number of floors.
Depth of the garage is assumed of 24 feet, width depends upon the number of cars, for a one, two and three car garage, the width will be 12, 22, and 33 feet respectively.

Figure 6: Rules to Auto-Build a House

2.1.6. Polygon Extrusion

The user that wants to more accurately enter the geometric conditions of the building can use a CADD-like interface (Figure 7) to draw the outline of the conditioned spaces and rooms. This feature is already bundled in the foundation classes tier and is incorporated in existing versions of VisualDOE. Polygons can also be created in CADD programs and imported. This feature provides an easy method to correctly position and size exterior surfaces in the energy model. Again, this is a more advanced feature that is not required by the neophyte. Expert users are also able to create models with tilted surfaces, vaulted spaces, cathedral ceilings, varying wall heights, and other features that break the mold of polygon extrusions.



A CADD-like interface enables the user to enter the outline of conditioned spaces, garages, and other elements.

The sides of the polygons are extruded vertically a distance equal to the floor – to- ceiling height to create the exterior walls.

Clipping the polygons automatically creates horizontal surfaces such as roofs, floors, ceilings, and interior floors (separating the first and second floors).

Figure 7: Polygon Extrusion Method of Creating Building Models

2.1.7. Attics Crawlspaces and other Unconditioned Spaces

The program provides tools to easily create these unconditioned spaces with all the necessary, calibrated inputs. Such spaces are automatically created when the wizards are used. Users are able to create attics, sloping (vaulted) ceilings, and other forms that are typical of residential buildings.

2.1.8. Library Editors

The program has an extensive library of elements that can be easily referenced by the user to simplify input. Examples include schedules of operations, construction assemblies, utility rates, and other elements. In addition to being able to select standard elements from the library, users are also able to create their own objects through editors provided with the software. The following bullets describe some of these libraries and editors available for making additions or modifications.

Schedule Editor. In hourly simulation programs, everything is scheduled including people, lights, equipment, thermostat settings, etc. Setting up these schedules can be one of the most time consuming steps in using a program like DOE-2. Standard patterns of residential building operation are included in a library so that the user

only has to choose an occupancy pattern such as “professional couple” and a whole host of schedules and other information will be automatically triggered. However, the expert can use the Schedule Editor to create special and unusual schedules.

Fenestration Editor. The library contains a considerable array of window types, sizes, and constructions for the user to choose from. However, the expert (or window manufacturer) can use the Fenestration Editor to create special windows that do not exist in the library. Manufacturers can use the Fenestration Editor by itself to enter their entire product line for posting on a website. Then, for example, users might be able to go to the Andersen web site and download data for a particular window.

Utility Rates Editor. The Utility Rates Editor is one of the most important library editors as we enter the era of unregulated electric power. If a homeowner wants to evaluate a utility rate, information about the rate must exist, including the time periods when energy or demand charges vary and the prices charged during these time periods. A number of rate schedules will be shipped with the program if they are available, but the Utility Rates Editor may be used to create rates as new offerings are made by energy service providers.

Constructions Builder. The program is shipped with a wide range of wall, floor, roof, and ceiling constructions representing typical ways that residential buildings are built in California. Most users are able to meet their needs by making a selection from the standard libraries. However, expert users can launch the Constructions Builder and create unusual constructions that do not already exist in the library.

2.1.9. Information Flow

The user interface is the portion of the program exposed to the user. The user interface includes forms where data is entered by the user. Each form has controls such as text boxes, drop-down list boxes, and slide bars that are used to specify information about the building. The User Interface communicates with the foundation classes software tier, which encapsulates most of the functionality of the program, producing the input files for the calculation engine, extracting results, and performing miscellaneous other functions. Figure 8 shows this flow of information. It illustrates the relationship between the user interface, the foundation classes, and the calculation engine.

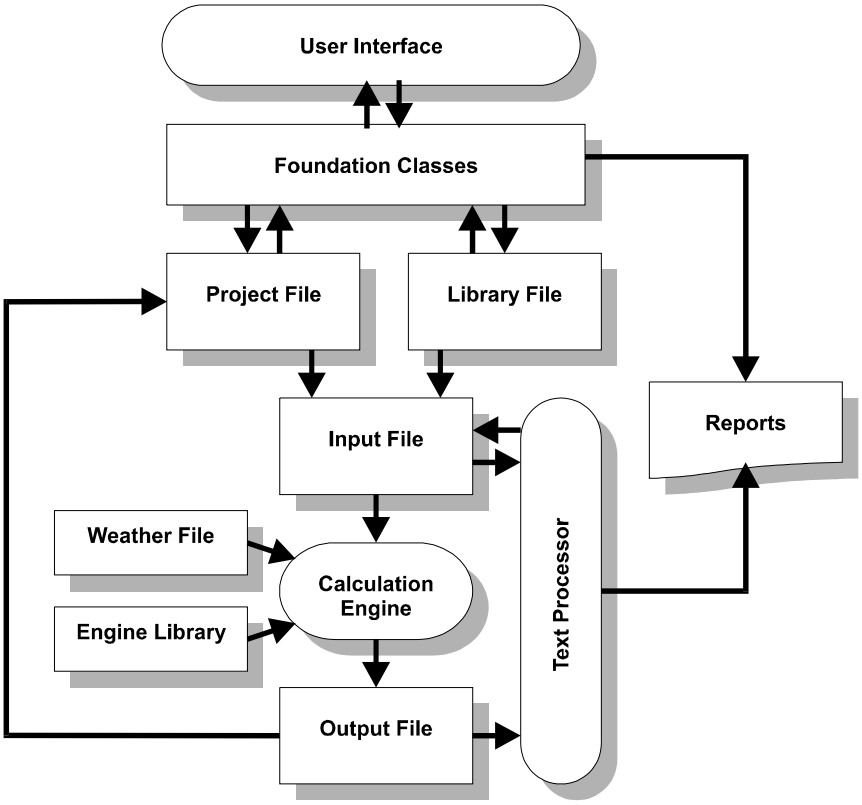


Figure 8: Information Flow

2.1.10. Graphic Display of Building Model

The user interface produces a visual representation of the building model (Figure 9). Even if one of the simplified wizards is used to produce the input file, a visual representation is available. The graphic image produced will, at a minimum, be an isometric representation in a viewer window. The user can rotate and move the image to look at different sides.

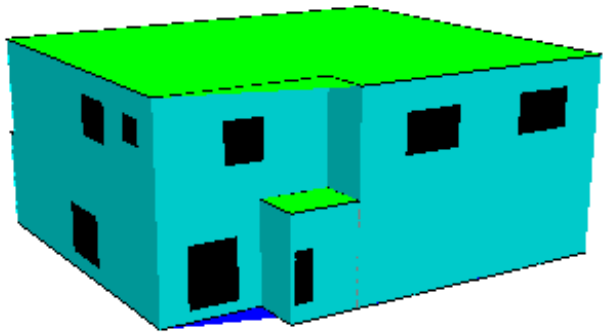


Figure 9: Three Dimensional View of the Model

2.1.11. Graphic Display of Simulation Results

The results of the simulation may be displayed in several forms. Figure 10 is an example of the type of graphic results presented by the program.

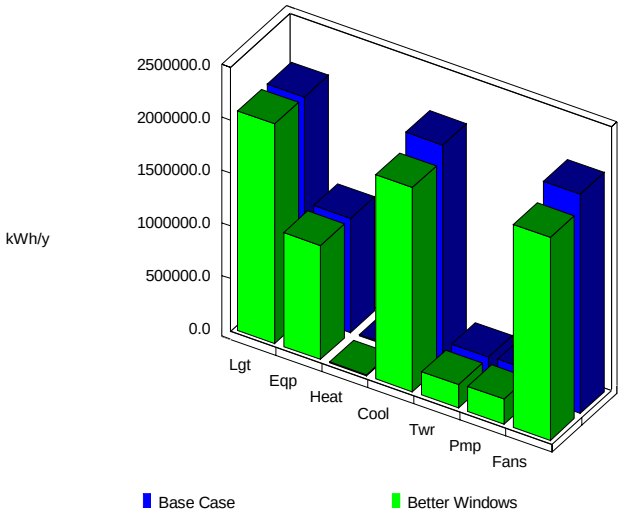


Figure 10: Graphic Results - Electricity End Uses

2.1.12. HVAC Ducts

Losses from HVAC duct work is an issue of critical importance in residential buildings. Many studies have identified duct leakage and conduction losses as very significant contributions to the heating and cooling loads in buildings. As DOE-2.1E does not have a duct model, duct loss is taken into account as a correction factor to the heating / cooling system efficiency based on the duct location, and whether it is insulated and sealed specified by users.

2.1.13. Lights and Appliances

Lights and appliances account for a significant amount of energy use in a residential building. The tool provides the interfaces (Figure 11, Figure 12, and Figure 13) for users to enter detailed data. Another way for the user to specify lights and appliances is to choose a lifestyle, and then the program defaults this data.

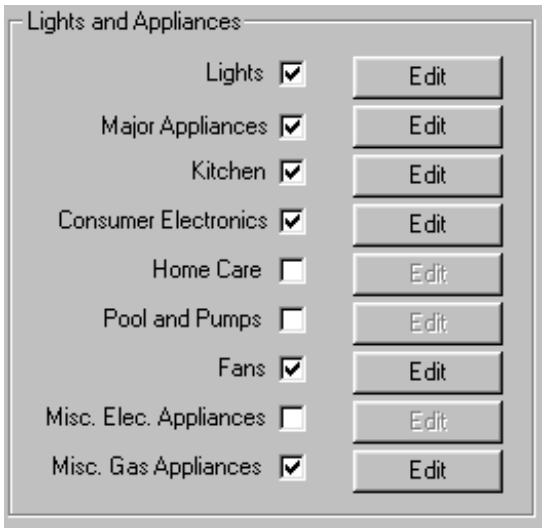


Figure 11: Lights and Appliances

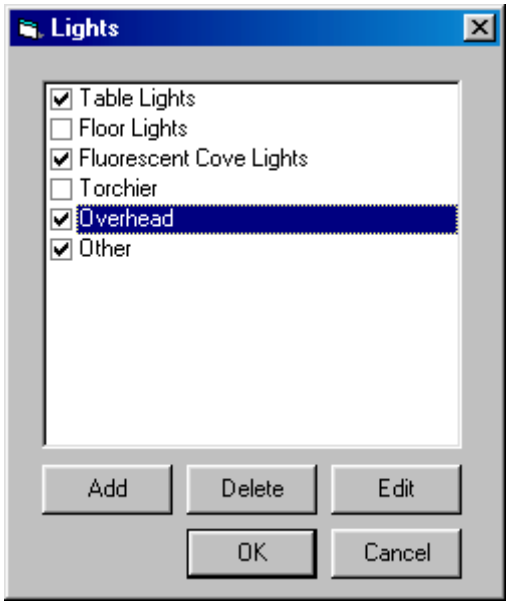


Figure 12: Lights Categories

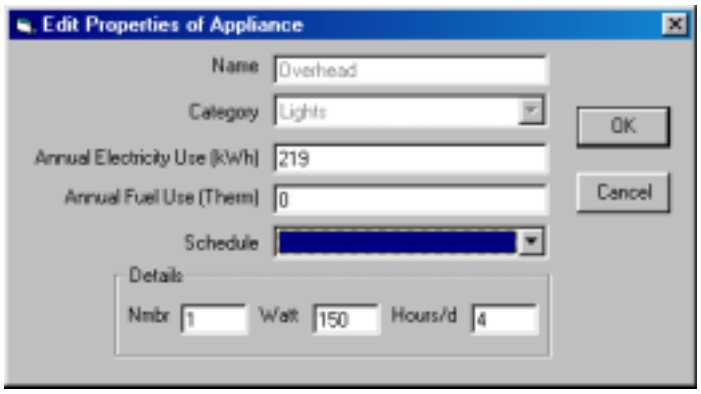


Figure 13: Properties of Lights and Appliances

2.1.14. Interfaces to Other Software Applications

The software can interface with other programs. For instance, the graphic images can be copied to the clipboard and pasted into other applications. Tables of results can be exported to spreadsheets and Adobe PDF documents. And, the geometry of the building can be developed in a CADD program and imported to this software. Appendix IV and Appendix VI provide detailed information on the program.

3.0 Project Tasks

The following section describes the specific tasks that were performed to achieve the goals of the project.

3.1. Task 1 - User Groups

The purpose of this task was to gain information from persons who are potential users of the program. This information was used to help define features of the program and to give form to the user interface. User groups were also encouraged to comment on and test the software at the conclusion of alpha coding and beta coding. These groups did not all have the same user needs. Information from the user groups was critical in helping to determine the look and feel of the user interface and to define the level and depth of extensibility.

User groups included:

- Homeowners who were interested in evaluating proposals from energy service providers;
- Marketing personnel for energy service providers who wanted to better understand residential energy use profiles;
- Manufacturers who wanted to design and develop products, controls, and equipment for the residential market;
- Architects and building designers who wanted to evaluate design strategies and alternative specifications;
- Home builders and residential contractors who were considering alternative equipment and designs.

Two focus groups were conducted with a representative sample of homeowners. One of the focus groups was held at the beginning of the project, prior to development of the specification. A second focus group was held during development of the specification, at which time a mock-up of the user interface was provided for comment and evaluation. Each focus group included eight to ten participants and lasted about two hours. A report was produced at the conclusion of each focus group summarizing the findings and making recommendations for development of the tool.

At the first focus group, participants were asked to imagine having to decide between energy service providers and whether or not to make improvements to their home. In this context, we obtained information on how useful they think the program would be to them, which features they wanted to see, how much they would be willing to pay for such a program, and other insights helpful in the development of the tool. In the second focus group, a working program was demonstrated, with emphasis on the easy-to-use wizards. The purpose was to get feedback on how to make the program features more useful and understandable.

A series of about six in-depth interviews were held with design professionals, product manufacturers, and homebuilders. Each interview session lasted approximately 40 to 60 minutes and was audio-recorded. The group was picked somewhat at random, with consideration of location, experience, and interest. The individuals were shown some ideas on what the tool might look like from their perspective, and their feedback was used in developing

the specification for the tool. The alpha and beta versions of the tool were also given to this group for evaluation. We made personal contacts to encourage their testing of the program and to solicit their reactions.

All of the research participants were pre-recruited at random and were not limited to individuals with whom the team had previous relationships. In-depth interview and group discussion guides were specifically developed for each market segment. The focus groups were conducted in facilities located in San Francisco that allow for client observation and audio recording. The one-on-one, in-person, in-depth interviews were conducted in San Francisco at the participants' places of work.

Appendices II and III present detailed user group results.

3.2. Task 2 - Background Research

Background research was conducted to develop patterns of operating conditions, categories of equipment performance, special modeling techniques, and other data and information needed to accurately model low-rise residential buildings. Appendix I contains reports produced in each of the subject areas.

3.3. Task 3 - Software Specification

The specification identified all the features of the user interface and communicated the look and feel of the program. Based on previous experience, the best way to communicate the look and feel was to create a mock-up of the user interface. While not all the controls and features of the forms were functional, they were adequate to convey the general operation of the program and to show the interaction of forms and data entry procedures. The mock-up was the first step in preparing the specification and also served as a tool in soliciting feedback and input from the Energy Commission and from the user groups identified in Task 1.

Once feedback was obtained, the final specification was produced. The specification also identified information to be included in the software library. It described the functionality of the program and the various modes of operation. The document outlined the workings of the user interface, including screen mock-ups. The final specification was strongly influenced by the previous two tasks.

3.4. Task 4 - Alpha Coding

In this task, the code behind the user interface was developed. Using the resources of the foundation classes, the code behind the user interface was developed. The alpha version of the program incorporated about 90 percent of the functionality and features of the program. At the conclusion of alpha coding, a working program was tested and reviewed by the Energy Commission and the user groups identified in Task 1. The user interface was written primarily in Visual Basic 6.0. The code operated in a 32 bit operating system, which required either Windows 95, 98, Me, or 2000. The foundation classes software tier was written in Visual Basic 6.0 with some portions written in Visual C++.

3.5. Task 5 - Alpha Testing and Review

The alpha version of the program was tested in order to identify any necessary revisions. At this phase, the program was buggy and some features were not functional. Eley Associates in-house staff did most of the alpha testing. The California Energy Commission staff provided additional testing through a hands-on training program. A written report was produced at the conclusion of the testing, which described the findings, comments and recommended changes resulting from the in-house testing and hands-on training.

3.6. Task 6 - User Documents and Help System

The user documents and help system were developed at this point. The user documents serve as both a reference for experienced users and a tutorial to get persons started using the program. The tutorial section leads users through a series of lessons that teach each of the important concepts. At the conclusion of the lessons, the user emerges with an understanding of the fundamental concepts and underlying principals of the program. The reference section includes a glossary of terms that are used in the documentation as well as a reference page for each form or tab of the user interface. The help system is context sensitive, which means that when the F1 key is pressed, help is provided for the portion of the program or the control that is active.

The documents include technical information as well as help information. Examples of technical information are the methods used to model attics, ducts or other building features, and how the schedules of operation are developed. In a sense, the technical documents summarize the findings of the background research reports, insofar as they became features of the program.

3.7. Task 7 - Beta Coding

This task included implementing the changes identified in the alpha testing, fixing all known bugs, and completing coding of the program. At the conclusion, a beta test version of the program was produced that implemented all the functionality of the specification, as modified in the previous tasks. One of the activities during beta coding was to extend the error trapping and data validation features of the program. These features make sure the data entered by the user is within an acceptable range and in an appropriate format.

3.8. Task 8 - Validation

In the validation task, we compared billed utility data on residential energy use to the results of the tool. The validation process occurred at the whole building level, where monthly and annual utility bills were compared to the results from the model. The purpose of this task was to add credibility to the program and to provide a methodical means for testing. Appendix V compares the results of the program to the measured data.

3.9. Task 9 - Beta Testing and Revisions

This task finalized the program and made any changes identified as part of the validation process. As part of wrapping up the project, all comments and questions from the client group or others received responses. The final residential energy analysis tool was delivered along

with the print documentation, the help system, the installation program, the climate data, the sample files, and other information. The software was delivered on a CD. User documents were also delivered in a PDF format.

4.0 Project Outcomes

This project produced a comprehensive residential energy analysis tool (computer software) that performs a detailed hourly simulation of energy use in houses. The tool combines the power of the DOE-2.1E v110 simulation engine with a user-friendly graphical interface to create house models and perform detailed energy calculations.

The tool has two versions, with the Professional version for architects and engineers and the Lite version focused on homeowners, school students, and those with little knowledge of building and energy. Both versions share the same foundation software components. User interface for the Lite version is relatively straightforward, incorporating a wizard to help users describe the house and its service systems. The Professional version's user interface enables users to create a house based on some brief inputs, and then customize the house in detail.

The tool can be used to evaluate utility offers and explore energy saving potentials by improvements of wall insulation, windows, natural ventilation, air ducts, heating and cooling systems, lights and appliances, water heating system, etc.

Main outcomes of the project are:

- HomeEnergy, the Professional version of the software tool
- HomeOwner, the Lite version of the software tool
- Tool documentation including the online help system, tutorial, and user manual

5.0 Conclusions and Recommendations

5.1. Conclusions

The project achieved its goal of producing a better analytical tool for evaluating and recommending energy efficient improvements in residential buildings. In the process we learned that it is very difficult to target such a tool to homeowners. Our first attempts were poorly received in the focus groups, requiring a completely new approach based on wizards and more simple techniques. The tool was better received by design and construction professionals, but we were unable to address one of the main issues that they raised, which was to make the tool work for energy code compliance. Most of the architects and contractors interviewed as part of the project indicated that they would be more inclined to use the tool if it helped them comply with California's energy efficiency standards.

5.2. Benefits to California

Benefits to California include:

- Architects and engineers can use the tool in early design phase of residential houses to incorporate cost effective energy efficiency equipment and systems.
- Homeowners to evaluate various utility offers and energy efficiency measures when their houses are to be improved to reduce energy use can use the tool.
- The tool can be used as an education tool for students to understand energy efficiency of buildings and environment.

5.3. Recommendations

We recommend that the software be modified to work as a code compliance tool. This would address a need identified by design professionals and contractors during our interviews.

There are also some technical areas that need additional attention. These include air distribution systems, combined hydronic space and water heating systems. The DOE-2 calculation engine is inadequate in modeling these systems. Calculation procedures are contained in the Residential ACM Approval Manual should be considered to supplement the DOE-2 algorithms.

The homeowners' version of the software was developed in response to focus group comments and substantial changes were made. Additional focus groups or market studies would enable us to verify that the changes address the issues that were raised in the initial focus groups.

6.0 References

References are provided in each of the deliverables (see appendices).

Appendix I

Software Specification

Appendix II

User Manual

Appendix III
Background Research

Appendix IV
Validation Report

Appendix V

A Qualitative Research Report on Homeowners' Reactions to the Home Energy Advisor

Appendix VI

Residential Building Professionals' Reactions to the Home Energy Advisor

Appendix VII

Product Readiness Plan

Appendix I

Software Specification

Software Specification

Residential Energy Analysis Tool
CEC Contract # 500-98-025

Deliverable for Tasks 2.3.4

October 11, 1999

Prepared by:

142 Minna Street
San Francisco, CA 94105

Preface 1

User Interface 1

Overview 1

Main Screen 1

Interface Components 2

Menubar 2

Toolbar 4

Statusbar 4

Graphic Images 4

General Tab 4

Shape Tab 5

Construction Tab 7

Opening Tab 8

Lights and Appliances Tab 10

Heating and Cooling Tab 11

Hot Water Tab 13

Software Architecture 14

Overview 14

Simulation Engine 14

Library Management 14

Data Structure 14

Components and Classes 15

New Properties and Methods for VisualDOE Foundation Classes 16

eaRoot Component 16

eaLoads Component 17

eaConst Component 17

eaOpn Component 17

eaHVAC-f Component 17

eaDHW Component 17

New Classes Descriptions 17

eaLoads Component 17

eaKernel Component 19

Preface

This document is deliverable for Task 2.3.4 of the project. This specification is evolved and expanded from the Task 2.3.1 Deliverable (Interface Mock-up). Revisions have also resulted from review and input by Eley Associates staff, the CEC project manager, and other design professionals who work closely with Eley Associates. This specification covers the design of the User Interface and the Software Architecture. Four separate specifications are attached in the Appendices.

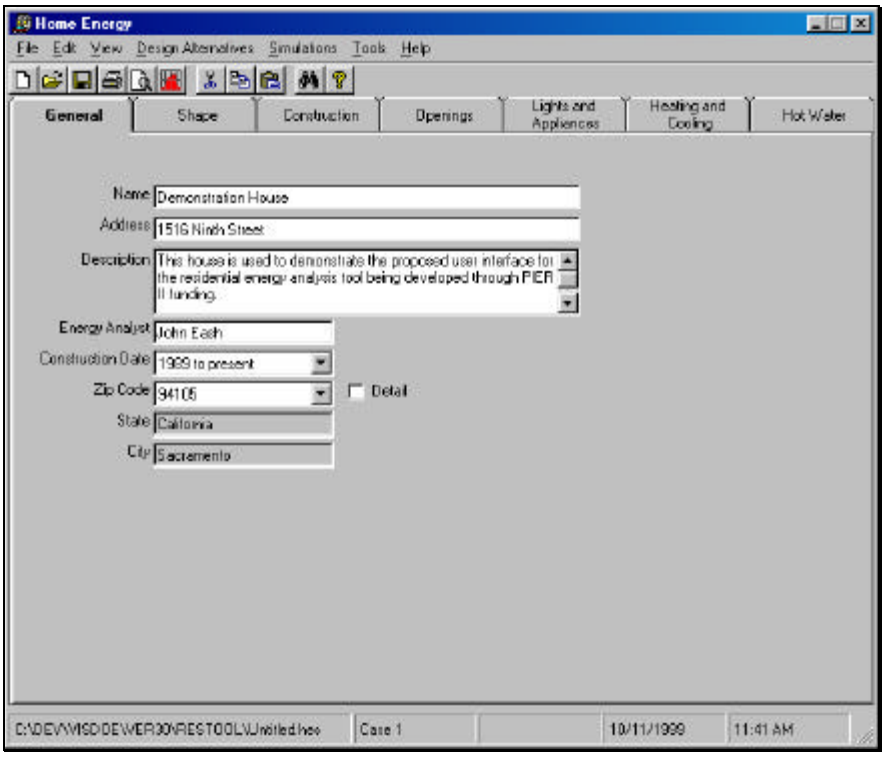
User Interface

O v e r v i e w

The challenge in the design of the user interface is to enable a variety of levels of users to use the program. At the simplest level, a high school student should be able to user the program to evaluate energy use in his/her house. However, the program also needs to offer features that are useful to architects, building product suppliers, engineers and energy consultants. The approach is to start with a simple interface (for the high school student), but provide “drill down” features that gradually expose more and more features. “Drill down” is provided through a series of detail checkboxes or buttons.

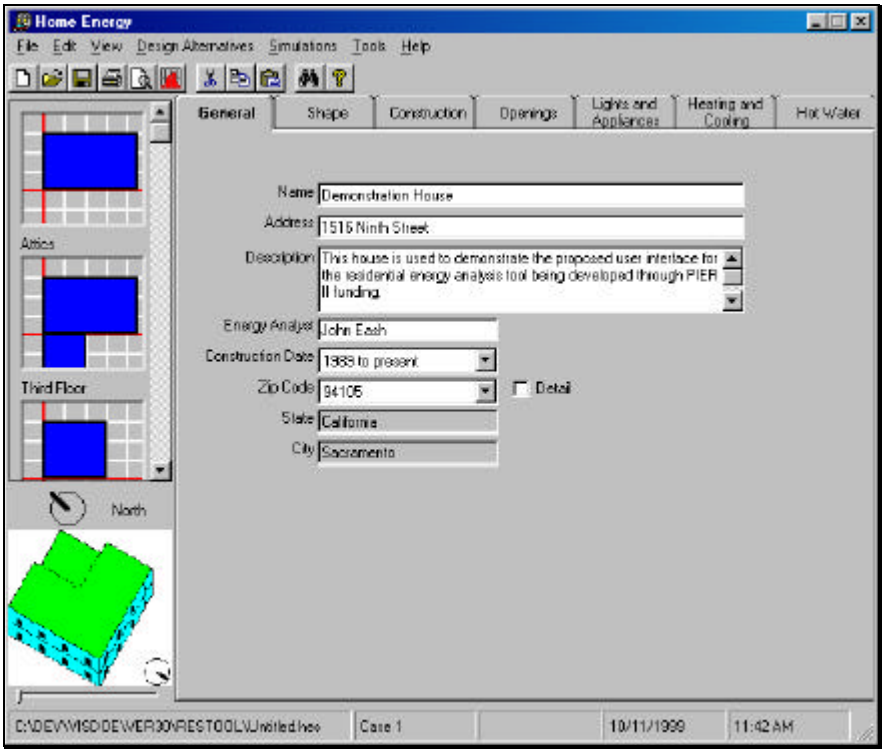
M a i n S c r e e n

The main form of the HomeEnergy user interface has the typical menu bar, toolbar, and several tabs for user input. A status bar is located at the bottom of the form. The tabs or folders organize user inputs in the following categories: General, Shape, Constructions, Openings, Lights and Appliances, Heating and Cooling, and Hot Water



Graphic images of the house model are shown if the user enables Graphic Images in View menu. These graphic images are visible for all the tabs but behave a little differently, depending on

which tab is selected. The images include a series of plan views that can be scrolled up and down if they do not all fit on the screen, a north arrow that graphically shows the orientation of the house, and an isometric view that shows the elevations of the house in three dimensions. The isometric view image has a scroll bar so that the user can rotate the house to expose different sides.

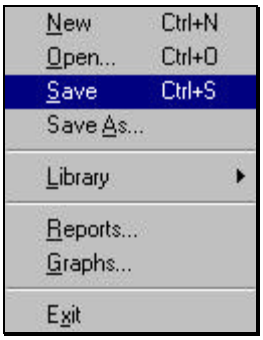


Interface Components

Menubar

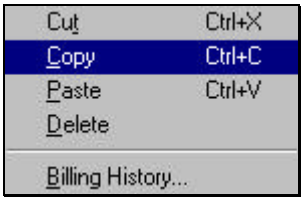
The program has a menu bar with the following options.

The **File** pull-down menu is used to open and save project files, view and print reports, manage library, and display graphs or simulation results. These File menu choices are the same, no matter which tab is current.



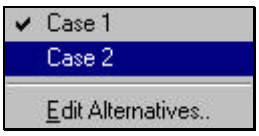
The **Edit** pull-down menu behaves differently depending on which tab is current. It has the standard cut, copy, paste and delete functions. In addition, existing homeowners can enter data

on how much energy their house has used in the past. This data will be used to calibrate the energy simulation model. Monthly electricity, gas and peak electricity (optional) can be entered.

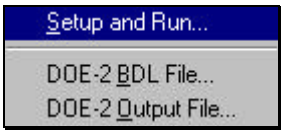


The **View** menu is used to turn the 2D/3D house model on and off.

The **Design Alternatives** menu is used to create new design alternatives; select the design alternative that you want to edit; and to perform other functions.

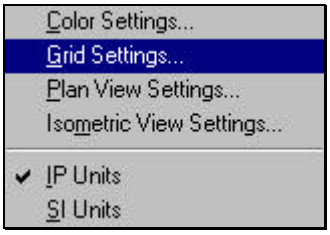


The **Simulations** menu is used to setup and run simulations. User can also browse the DOE-2 output file for each DOE-2 report, and DOE-2 BDL file to locate errors if a simulation fails. Advanced users can make edits directly in the DOE-2 file.

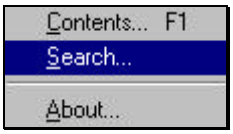


The **Tools** menu option allows users to create schedules of construction assemblies, windows, doors, skylights, schedules of operation and other simulation elements. These schedules are not necessary when the program is used at the simplest level.

Tools | Options enables users to choose the palette of colors for display of plan and isometric views of the building. Grid spacing and other grid properties can be specified. For the plan and isometric views, users can choose the details that they want to display.



The **Help** menu provides context sensitive online help.



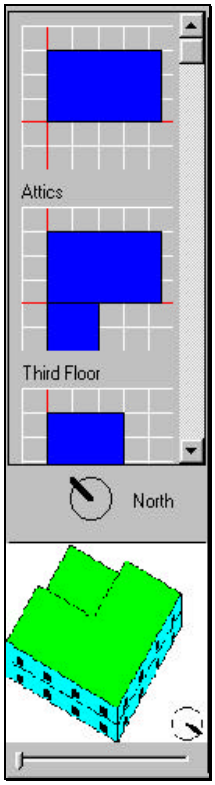
Toolbar

The tool bar has buttons for handling common functions such as File New, File Open, File Save, Print, Print Preview, Graph Results, Cut, Copy and Paste and Help. Everything on the tool bar can also be done through the pull-down menus.

Statusbar

The status bar provides information and feedback on what you are doing. It shows the file that is open, the design alternative you are working on, unit of the focused input, along with the current date and time.

Graphic Images

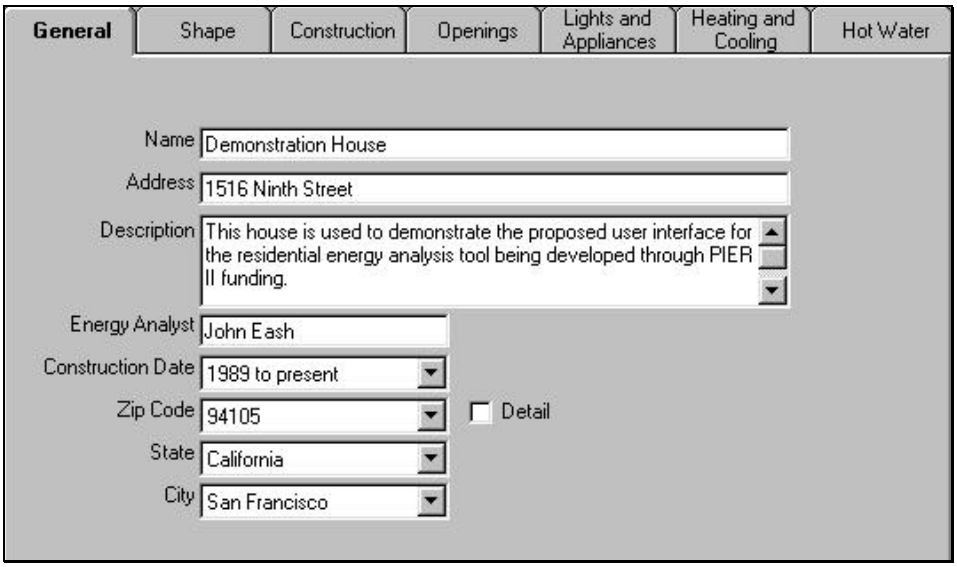


The graphic images include plan views of the house, a north arrow, and an isometric view. These graphic images are not generally displayed for users that do not use the more advanced features. However, for users who describe their own building geometry, the graphic images provide useful feedback about building shapes and dimensions. They are also an editing tool that lets users choose a space, surface or other element. A selected element is highlighted, whether it was selected by clicking on the image or through other means. When the shape view is current (and Detail is checked), you can select a block or group of spaces on a particular level. When the Constructions or Openings tabs are current, the selected façade or wall is highlighted.

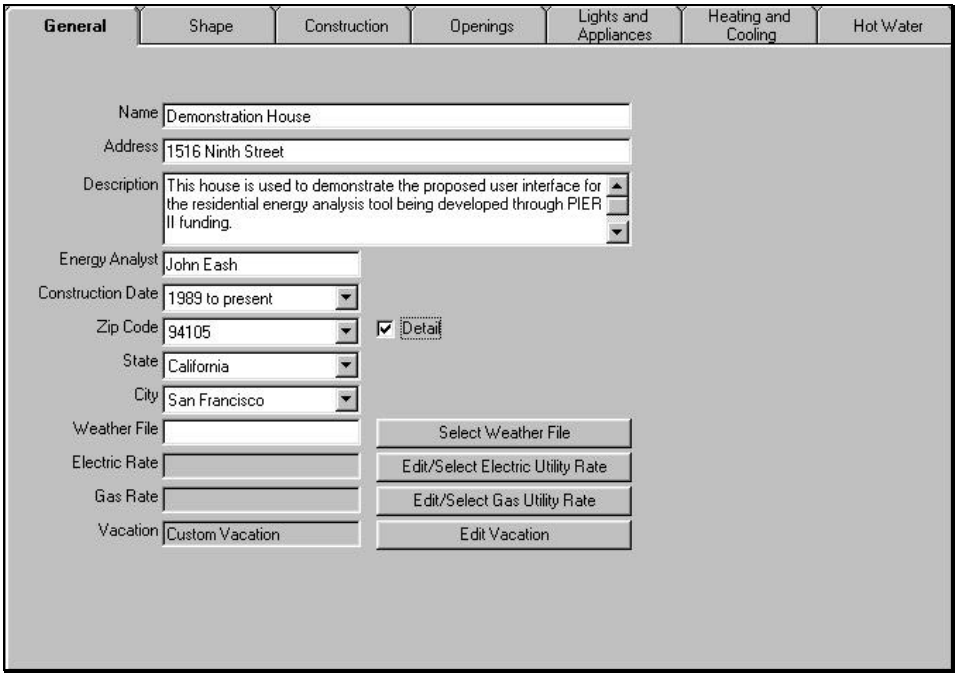
The plan views are located in a view port that shows about three plans at a time. If the building has more than three plans, a scroll bar on the view port allows the user to scroll up or down so that any plan can be viewed. The CvsDraw class from the VisualDOE foundation classes implements the isometric image.

G e n e r a l T a b

The General tab enables the user to enter general information about the project such as the project name and address. However, the main input on this form is the zip code. In normal mode (Detail not checked), the zip code determines the weather file and utility rates to use. With Detail not checked, the zip code is the only mandatory input on this General tab.

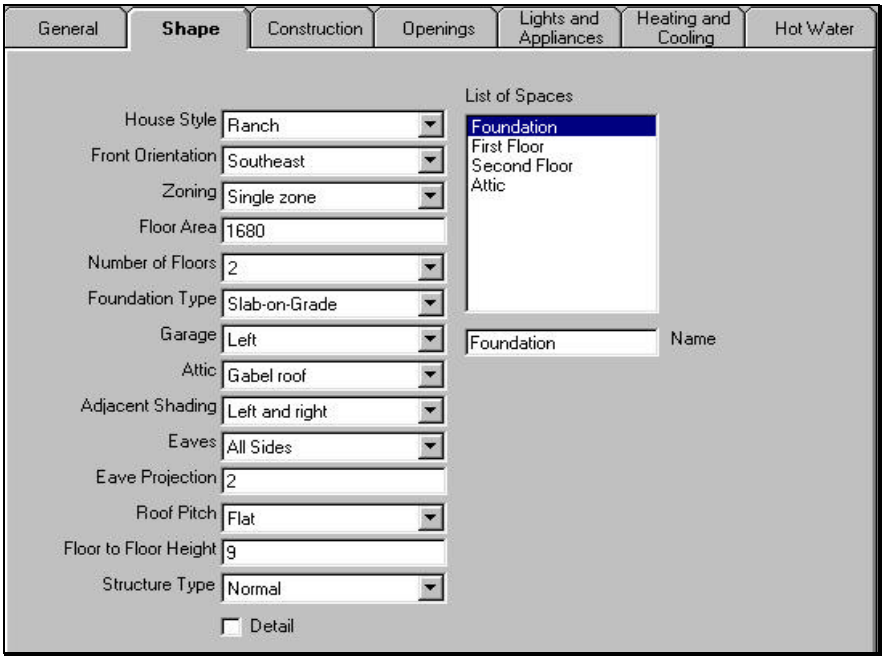


If Detail is checked, the user can select and edit the weather file, electric rate and gas rate, and holidays to observe. Command buttons appear that launch editors for weather data, electric rates, gas rates and holidays.



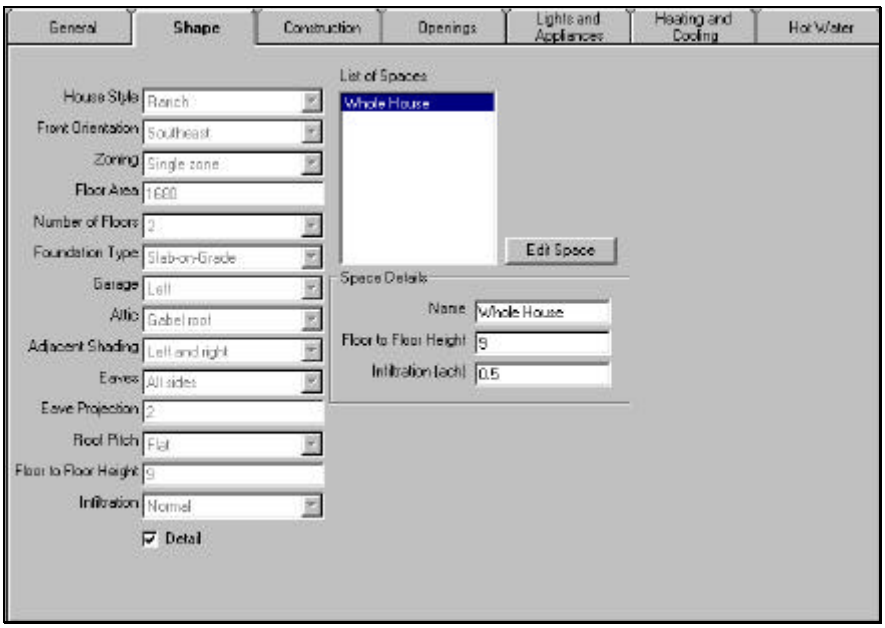
S h a p e T a b

The Shape tab is where the user can describe the shape of the house. Like all data entry screens in HomeEnergy, information can be specified at several levels of detail. At the simplest level, the user enters general information about the house such as style, zoning, floor area, number of floors, foundation type, the presence and location of a garage, shading from trees or neighboring houses, shading from roof eaves, floor-to-floor or ceiling height and other details. Making choices from drop-down list boxes enters all of this data. Extensive context sensitive help will be provided for each of the inputs. At the simplest level, the user does not have to specify dimensions or deal with the specific geometry of the house. HomeEnergy will create a simulation model based on the input provided.



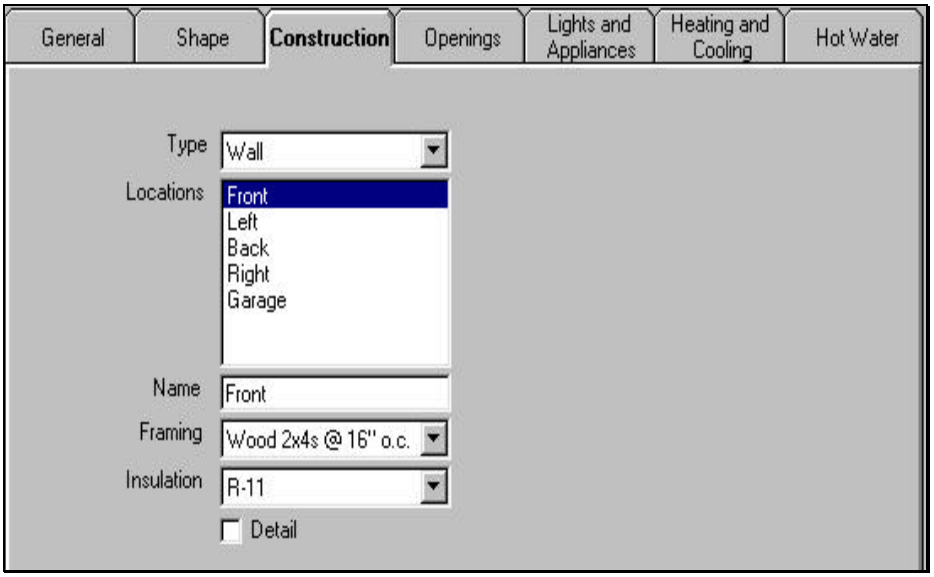
The graphic images will not generally be displayed when the shape of the house is being specified in the simplest manner. When Detail is checked, the behavior of the Shape tab changes. Most of the controls described for simple input are disabled. A list of spaces in the house are displayed in a list box. Users can add, delete or edit spaces. Several types of spaces are supported. Attics, crawlspaces and garages are examples of unconditioned spaces. The conditioned portion of the house can be modeled as one space or it can be subdivided into sleeping and living areas (following the rules of zonal control in the CEC Residential ACM Manual).

HomeEnergy supports a CADD like interface for editing the geometry of spaces. This editor will be modified from VisualDOE and enable users to draw the shapes of spaces, import data from CADD programs or enter the vertices of spaces. Many advanced features are provided such as created multiple rooms as rectangles and then merging these rooms into a single room. Facades can be split. Vertices can be moved or inserted and the geometry of each space can be edited with a simple easy-to-use graphic interface.



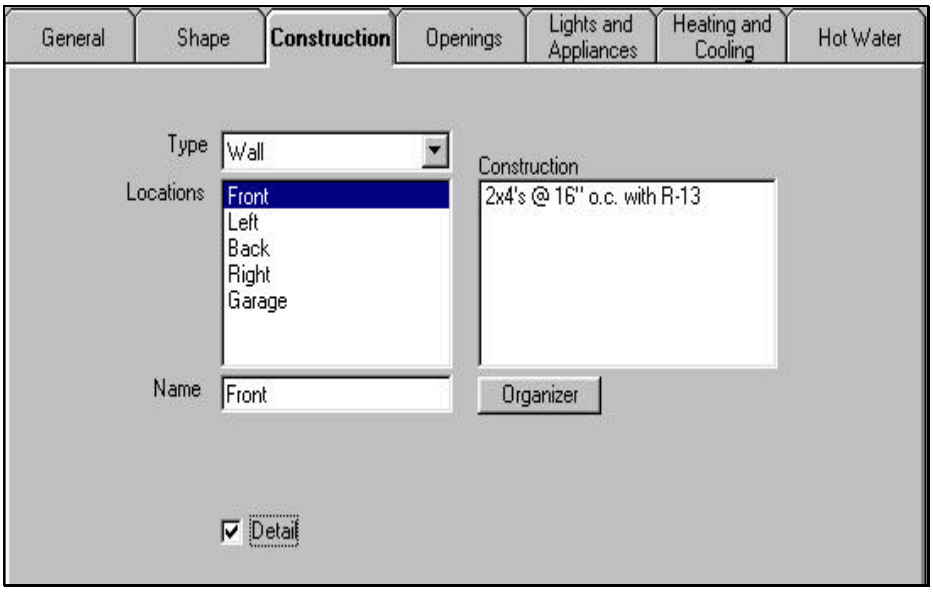
C o n s t r u c t i o n T a b

The construction tab is used to specify construction details for walls, roofs, ceilings, floors, and slabs. This tab is used to describe what the building envelope is made of. Like the other tabs information can be entered at multiple levels of detail. When Detail is not checked, the screen will appear like the following. The user selects one or more surfaces and using the Framing and Insulation drop-down list boxes, describes the salient characteristics of the surface. Wall surfaces are split by orientation so that a different construction can be assigned to different orientations, when appropriate.



When Detail is checked, the behavior of the form changes. The types and locations of surfaces are still displayed, but instead of describing constructions by selecting a choice from the Framing and Insulation dropdown list boxes, users select a construction from the project schedule. The project schedule is analogous to schedules, which are used on architectural drawings. With this approach, constructions containing complex assemblies such as radiant barriers, high albedo

surfaces multiple insulation levels and other features can be used in the model. HomeEnergy will be shipped with standard libraries of components to ease the burden of creating complicated schedules. With Detailed checked, the Constructions Editor and the Constructions Organizer can be launched from this form.

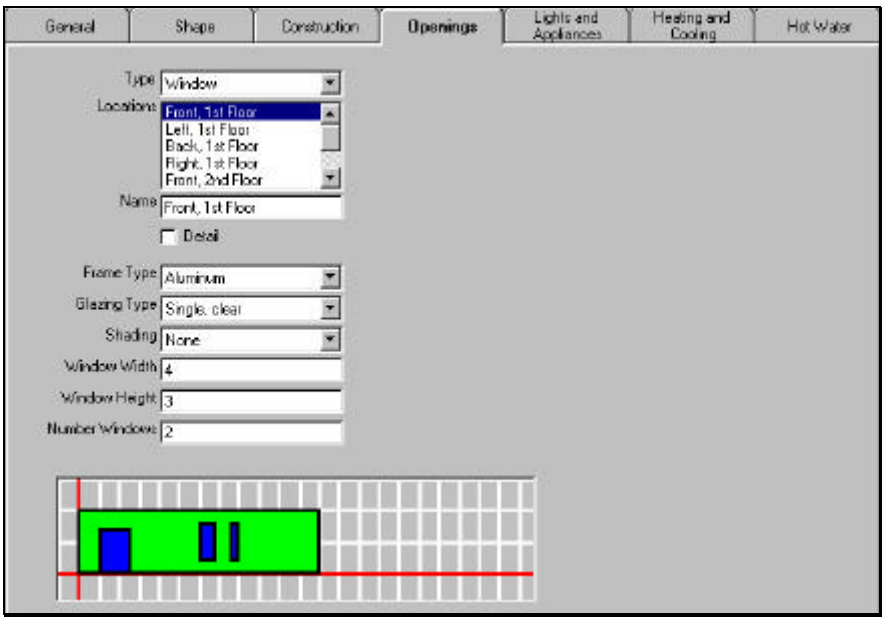


O p e n i n g T a b

Openings include windows, doors and skylights. Openings are associated with a particular surface. This way, the gross area or dimensions of the surface are specified once and these dimensions do not have to be adjusted each time an opening is added or removed from the surface. Openings inherit many properties from their parent surface such as orientation, shading conditions from adjacent buildings or trees, etc.

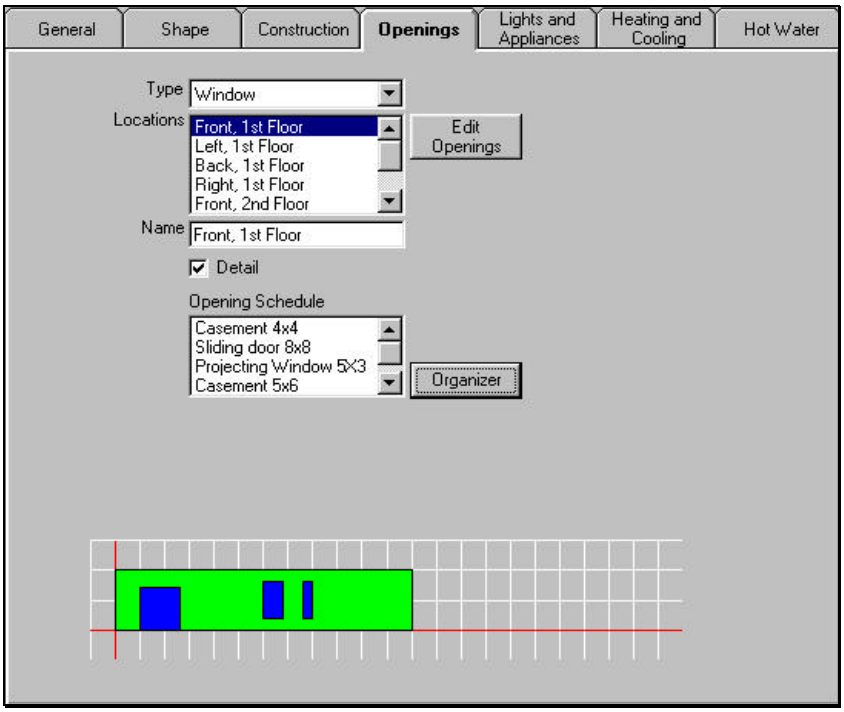
The openings tab can work in either a simple or detailed mode. The behavior of this tab is very similar to the Constructions tab. With Detail not checked, a list of surfaces will appear. This list includes wall, roof, floor, slab and other components of the exterior envelope. The user can select one or more of these components and assign properties. For windows, the properties include frame type, glazing type, shading from overhangs or side fins, window height, window width and the number of windows on the surface. Similar properties would be specified for skylights and doors.

A graphic image of the selected façade is displayed at the bottom of the tab. This shows the height and width of the surface and each of the openings that are assigned.



With Detail checked, the schedule of openings appears. The list of surface types and locations remains and one or more openings from the schedule is associated with each façade. In the detailed mode, the concept of schedules is used, similar to that used on architectural drawings. If the properties of one of the items in the schedule are changed, the change affects all the surfaces that reference this opening. Like on architectural drawings, this makes it easier to manage changes and assure accurate models.

In detailed mode, more than one type of opening can be placed and positioned on a façade. This is achieved through the custom façade editor, which is a component of the VisualDOE foundation classes. A command button appears to launch the custom façade editor.



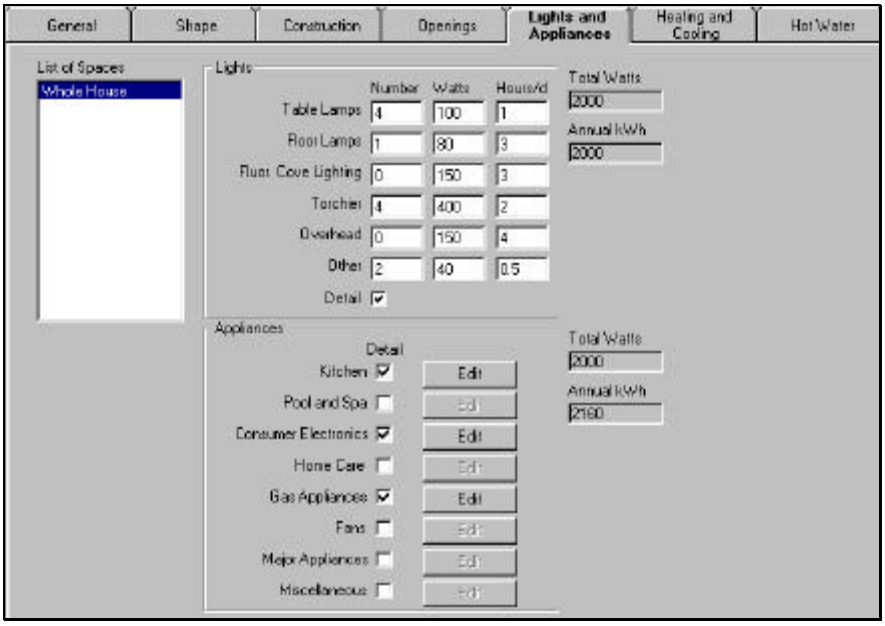
Lights and Appliances Tab

The lights and appliances tab is used to specify lighting and appliances that are contained in the house or grounds and that draw energy through the meters. A reasonable accounting of this energy is needed in order to calibrate the energy model results with energy bills. The form has a list of spaces. Lights and appliances are associates with each space. This detail is important since heat produced by appliances can be a major contributor to the cooling load of a space.

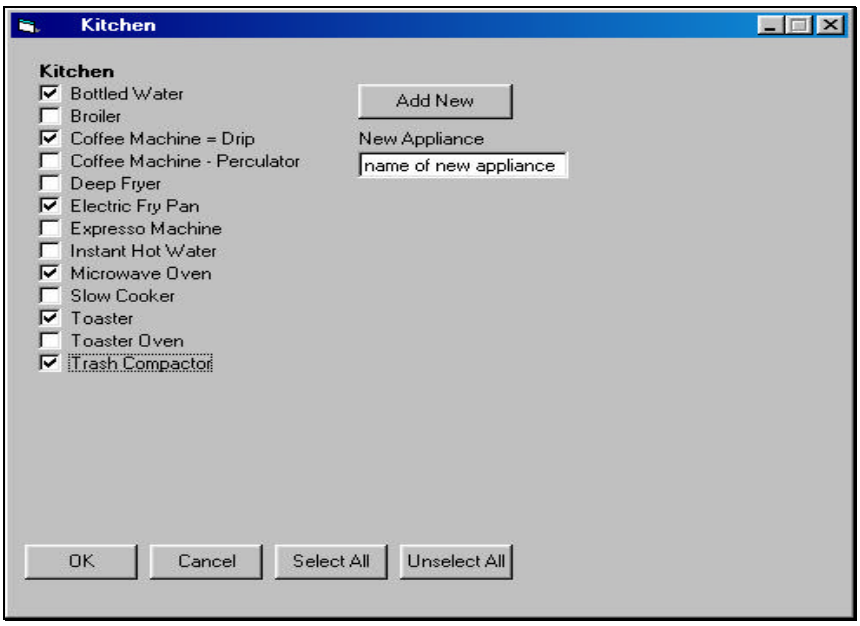
Like the other tabs, data can be entered in a simple or detailed manner. The simplest way to enter lighting information is to count the lighting fixtures of different types that are located in the various spaces. The categories of lighting fixtures are table lamps, floor lamps, cove lighting, torchiers, overhead lights, and other. HomeEnergy makes an assumption about the watts and hours of operation for each type of lighting fixture. When Detail is checked for lights, the user can enter the watts for each type of fixture and the average hours/day of operation.

The easiest way to specify appliance energy is to accept the HomeEnergy defaults. The user does this by not checking Detail for any of the categories of appliances. The defaults will be based on home size, occupants, and age.

This tab enables users to specify lights and appliances for the selected space. When the Lights Detail box is checked, watts and hours per day can be entered for corresponding lamp. The check box of Appliances indicates that whether there is specific type of appliance in the selected space. User can click Edit button to change the default items for that type of appliance.

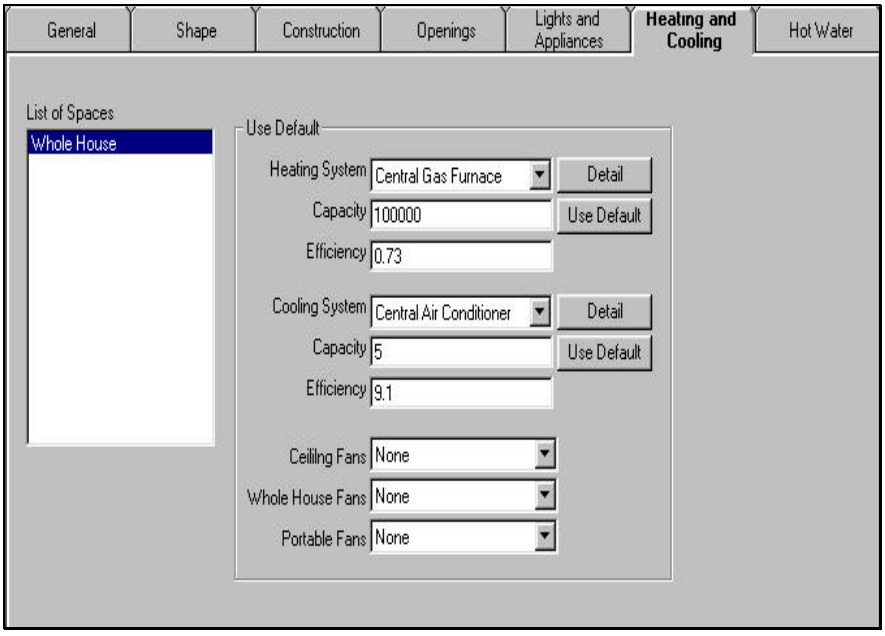


When detail is checked for a category of appliances, more information appears as shown below for the Kitchen category. A list of specific appliances are displayed and the user can check or not check whether the Kitchen has one of these. The user can also add appliances that are not in the list by clicking the Add New button.



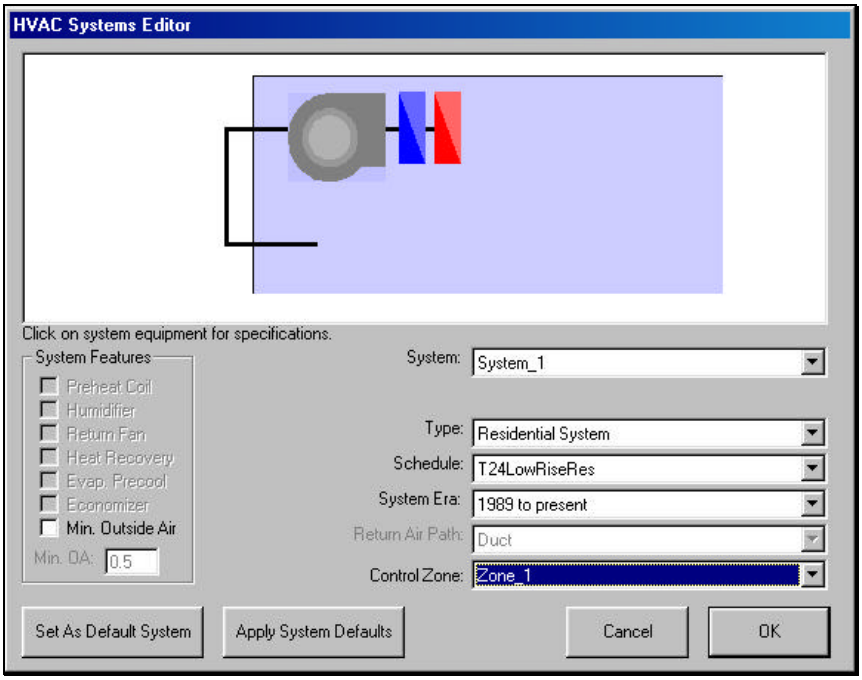
Heating and Cooling Tab

This tab enables users to describe heating and cooling systems for the selected spaces. The simplest way to specify heating systems is to select the system type (heating and/or cooling); the capacity or size of the equipment; and the efficiency. Many users will not know the capacity or efficiency of their equipment, and a Use Default button choose a value for them based on other inputs.



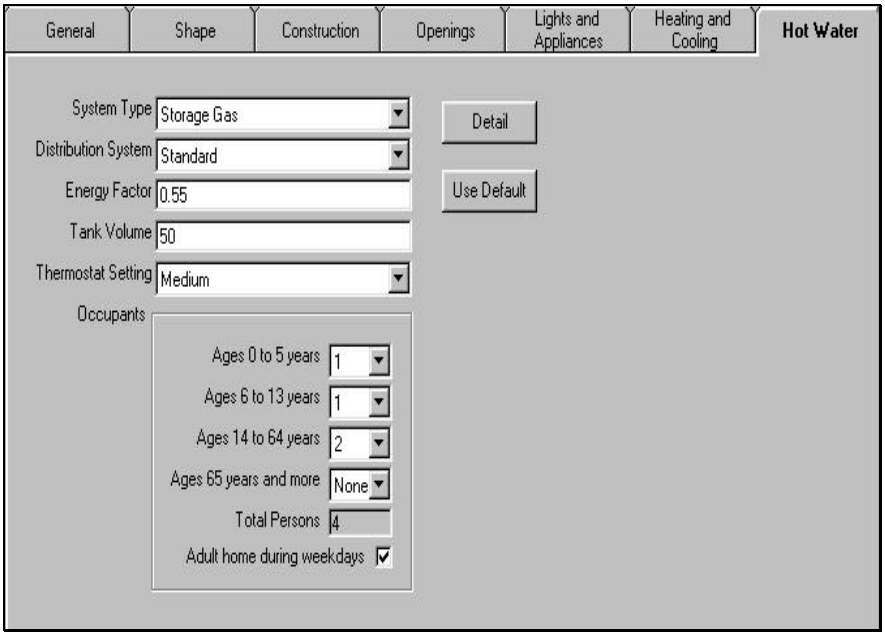
The Detail button allows users to specify detail about their HVAC systems. Advanced features can be specified such as variable speed compressors for heat pumps and air conditioners,

equipment-specific part-load curves, desuperheaters for heating hot water, crankcase heater operation, etc.

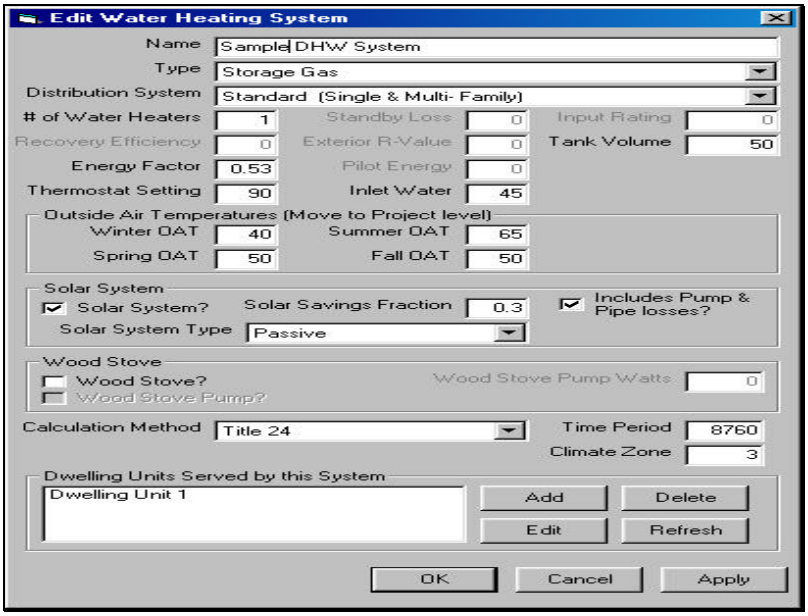


H o t W a t e r T a b

Information needed to estimate hot water energy use is specified on this tab. At the simplest level the user only has to choose a system type, distribution system, energy factor, tank volume and thermostat setting. The user can also click Use Default to set these values. All of this information should be available from a simple inspection of the water heater.



By clicking the Detail button, the user can specify more complex information such as multiple water heaters.



Software Architecture

The previous section described the graphic user interface for HomeEnergy. This section describes the software architecture

Overview

HomeEnergy will employ object-oriented programming methodology. Visual Basic 6.0 is the main programming language for this project. HomeEnergy will reuse most VisualDOE 3.0 foundation components. These software components are described in greater detail below, along with changes that will be made to serve the needs of HomeEnergy.

Simulation Engine

HomeEnergy will support multiple simulation engines. However, the native calculation engine will be DOE-2.1E. This version of DOE-2 is supported by LBNL and the U. S. Department of Energy. The program will also support DOE-2.2, but only as an option. DOE-2.2 is a proprietary program developed by LBNL, USDOE and James J. Hirsch. USDOE and LBNL have decided not to support the program or acknowledge its existence. USDOE is investing in another program which its expects to be the successor to DOE-2.1E. This program is called EnergyPlus and combines may of the features of BLAST and DOE-2.1E. EnergyPlus is under development and the release date is uncertain. The most recently announced release date is January 2001. The version of HomeEnergy to be developed under the CEC contract will not support EnergyPlus, but we will follow the progress of the program and try to make it easy to incorporate when it is available.

Library Management

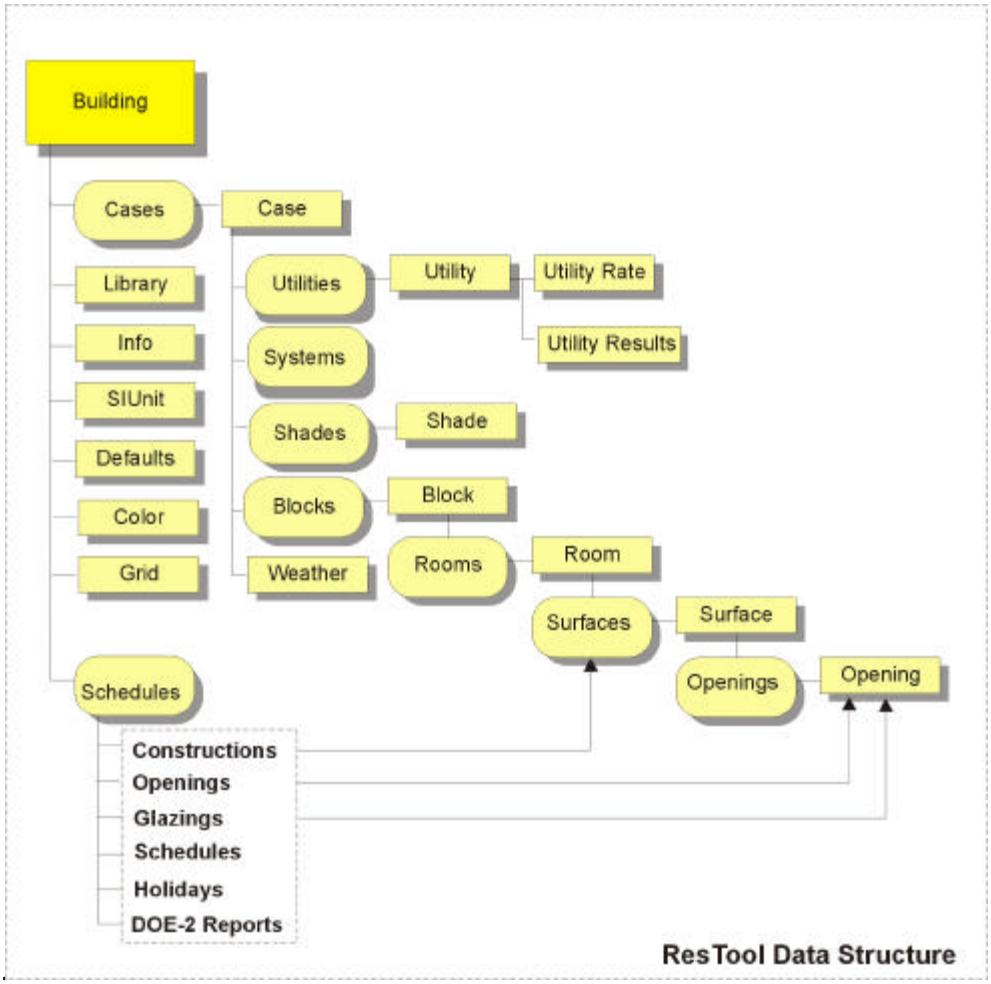
HomeEnergy will carry complete information to run simulations in project files independent of the library. The Organizer will copy data from the library to the project schedule, and enable users to edit data in the library or project schedule.

A research job is to collect information of zip codes, states, cities, and utility rates, and put them in additional tables to the current VisualDOE 3.0 library. With this data, users can select/type a zip code in HomeEnergy user interface, and the corresponding state, city, weather file and utility rate can be automatically assigned.

Data Structure

HomeEnergy has a data structure that is independent of the simulation engines. This feature enables support of multiple simulation engines. The data structure is the same as VisualDOE, and is shown in the following figure. In this diagram, the ovals represent collections of objects. The rectangles represent specific instances of objects.

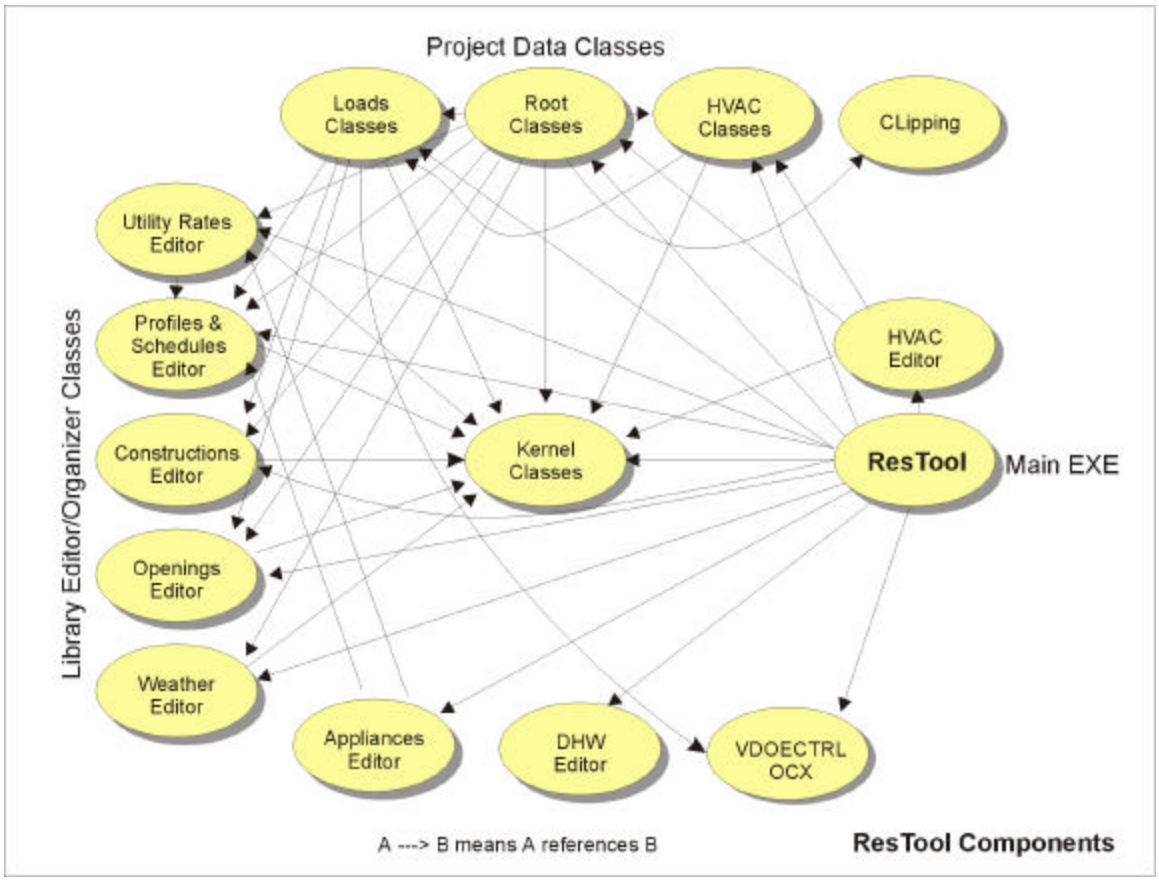
Starting with the building object, it has a collection of cases or design alternatives. Other information is carried at the building level such as defaults and schedules. Each case has collections of HVAC systems, utilities, exterior shades and blocks. Each case will carry its own copy of other project data, like utility rates, weather data, geometry data, HVAC system data. User can only work with one case (the current case) at a time. Each block has a collection of rooms. Rooms have a collection of surfaces. And, surfaces have a collection of openings. This many-to-one object hierarchy allows buildings of arbitrary complexity to be supported.



Components and Classes

Component technology is the state-of-the-art technology of computer software development. HomeEnergy will base on COM components, which makes it easier and cheaper to maintain and upgrade functionalities of HomeEnergy.

HomeEnergy will use most of the foundation classes from VisualDOE 3.0. Besides the main EXE program, HomeEnergy has thirteen DLL components and one OCX component. These components have internal references. The diagram of the HomeEnergy software components and their relationship to each other is illustrated below.



New Properties and Methods for VisualDOE Foundation Classes

eaRoot Component

CBldg

- *State (String)*. The name of the state.
- *Vacation (CHoliday)*. An object that describes vacation.

CCase

- *ResShape (CResShape)*. An object of CResShape.
- *ResOccupant (CResOccupant)*. An object of CResOccupant.
- *ResDHW (CResDHW)*. An object of CResDHW.
- *WeatherFile (String)*. The file name with full path of the binary weather file.
- *ResDetail (Boolean).* Specify whether the Detail check box at General tab of HomeEnergy is checked.

eaLoads Component

CRoom

Appls (CAppliances). A collection of appliances (including lights).

eaConst Component

CConstAssembly

Detail (Boolean). Whether Detail at Construction tab is checked for a construction.

IDFraming (Long). ID of the framing.

IDInsulation (Long). ID of the Insulation.

eaOpn Component

COpeningSch

Detail (Boolean). Whether Detail at Openings tab is checked for an opening.

IDGlazingFrame (Long). ID of the glazing frame.

IDGlazingMaterial (Long). ID of the glazing material.

eaHVAC-f Component

CCool

GetDefCoolSys. This method assumes a default cooling system (type, capacity and efficiency) based on the system built date and autosize assumption.

CHeat

GetDefHeatSys. This method assumes a default heating system (type, capacity and efficiency) based on the system built date and autosize assumption.

eaDHW Component

CDHWSystem

GetDefDHWSys. This method assumes a default DHW system (type, capacity, efficiency and thermostat setting) based on the system built date and occupant information.

New Classes Descriptions

The following paragraphs describe properties and methods of the new classes for HomeEnergy.

eaLoads Component

CResShape

*ObjType (String*6)*. Set to "RSHP01". It is used to identify a ResShape object when writing to and reading from a binary file. Automatically created.

- *HouseStyle (enumHouse)*.
- *Orientation (enumOrientation)*.
- *Zoning (enumZoning)*. Zoning type.
- *FloorArea (Single).* Floor area.
- *NumFloor (Integer).* Number of floors.
- *Foundation (enumFoundation).* Foundation type.
- *Garage (enumGarage).* Garage location.
- *Attic (enumAttic).* Attic style.
- *AdjacentShading (enumAdjacentShading).* Adjacent shading location.
- *Eaves (enumEave).* Eaves location.
- *EaveProj (Single).* Eave projection.
- *RoofPitch (enumRoofPitch).* Roof pitch.
- *FloorHeight (Single).* Average floor to floor height.
- *Infiltration (enumInfiltration)*. Infiltration feature.
- *Detail (Boolean)*. Whether Detail is checked.
- *Copy*
- *ReadFile*
- *WriteFile*

CResOccupant

- *ObjType (String*6)*. Set as “ROCC01”.
- *IDSch (Long)*. ID of the associated schedule.
- *NumOccupant (Single)*. Read only. The equivalent number of adult occupants.
- *AdultHomeWD (Boolean)*. Adult is home during weekdays.
- *NumPeople (1 to 4, Integer)*. Number of occupants between age 0 to 5, 6 to 13, 14 to 64, and 65 and more.
- *TotalHeatGain (Single)*. Read only. Total heat gains of all occupants.
- *TotalLatent (Single)*. Read only. Total heat gains of all occupants.
- *TotalSensible (Single)*. Read only. Total heat gains of all occupants.
- *AdultHeatGain (Single)*. Heat gains of an adult.
- AdultLatent (Single). Latent heat gains of an adult.
- AdultSensible (Single). Sensible heat gains of an adult.

CResEnum

A class of enumerations for CResShape.

eaKernel Component

Some common procedures and classes are added to eaKernel component to make them accessible to all other VisualDOE 3.0 components.

CHoliday

- *ObjType (String*6)*. Set to "HOL 01".
- *ID (Long)*. ID of the holiday set in the library.
- *Name (String)*. Name of the holiday set.
- *NumHolidays (Integer)*. Number of holidays.
- *Fixed (Boolean).*
- *Holidays (1 to NumHolidays, Date).* Date of each holiday.
- *Descriptions (1 to NumHolidays, String).* Description of each holiday.
- *Copy*
- *Edit*
- *ReadFile*
- *WriteFile*
- *SetUSHoliday([Year]).* This method sets the US standard holidays of the year passed. If the year is missing, the current year will be used.
- *ReadLib.* This method is not implemented yet, because changes need to be made in the VisualDOE library.
- *WriteLib.* Not implemented yet.

CGeneral

This global class contains some useful procedures for general use.

- *AddListItem (lvw As Variant, strLabel As String, ParamArray vntValue() As Variant)*
- *Avg (ParamArray X() As Variant) As Variant*
- *DaysOfMonth (iMonth As Integer, Optional ByVal iYear As Variant) As Integer*
- *ExistFile (sFile As String) As Boolean*
- *FillCbo (cbo As Variant, ParamArray vntX()) As Boolean*
- *GetNextID (ObjectArray As Variant, IsItACollection As Boolean) As Long*
- *GetNextIDFromLib (LibTbl As Variant) As Long*
- *IsArrayEmpty (vArray As Variant) As Boolean*
- *IsBetween (Value As Single, Bound1 As Single, Bound2 As Single) As Boolean*
- *IsLeapYear (ByVal intYear As Integer) As Boolean*

- *KeyPressFilterPositiveValue (ByRef KeyAscii As Integer)*
- *Max (ParamArray X() As Variant) As Variant*
- *Min (ParamArray X() As Variant) As Variant*
- *ReadField (ByVal fn As Integer, vntX As Variant)*
- *Setcbo (Ctrl As Variant, ByVal LookFor As Integer) As Boolean*
- *Sum (ParamArray X() As Variant) As Variant*
- *WriteField (ByVal fn As Integer, vntX As Variant)*
- *WriteFromFileToMemo (Fld As Variant, FileNameCSV As String)*
- *WriteFromMemoToFile (Fld As Variant, FileNameCSV As String)*

CUnit

This class handles unit conversion between SI and IP. Methods Convertxx and GetxxUnit have similar forms and parameters.

- *ConvertLength (Value As Single, InputUnits As enumLength, OutputUnits As enumLength) As Single*
- *GetLengthUnit (ByVal Unit As enumLength) As String*
- *ConvertArea, GetAreaUnit*
- *ConvertTemperature, GetTemperatureUnit*
- *ConvertVolume, GetVolumeUnit*
- *ConvertMassFlow, GetMassFlowUnit*
- *ConvertVolumeFlow, GetVolumeFlowUnit*
- *ConvertPower, GetPowerUnit*
- *ConvertEnergy, GetEnergyUnit*
- *ConvertSpeed, GetSpeedUnit*
- *ConvertMass, GetMassUnit*
- *ConvertDensity, GetDensityUnit*
- *ConvertPressure, GetPressureUnit*
- *ConvertUValue, GetUValueUnit*
- *ConvertConductivity, GetConductivityUnit*
- *ConvertSpecificHeat, GetSpecificHeatUnit*
- *ConvertHeatCapacity, GetHeatCapacityUnit*
- *ConvertHeatFlow, GetHeatFlowUnit*
- *ConvertLightingPower, GetLightingPowerUnit*

- *ConvertLightingDensity, GetLightingDensityUnit*
- *ConvertTime, GetTimeUnit*
- *ConvertDegree, GetDegreeUnit*

CUnitEnum

A class of enumerations for CUnit.

Appendix II

User Manual

HomeEnergy Software
User Manual

April 6, 2001

142 Minna Street
San Francisco, California 94105
(415) 957 1977 Voice
(415) 957 1381 Fax
www.eley.com

Contents

Contents i

List of Figures ii

What is HomeEnergy 1
- Introduction 1
- Software Components 1
- User Interface 2

System Requirements and Installation 5
- System Requirements 5
- Install HomeEnergy 5
- Run HomeEnergy 6

Using HomeEnergy 6
- Register Program 6
- Use Online Help 7
- Perform an Energy Analysis 7
- Create a House 8
- Define Vacation 12
- Define Constructions 13
- Define Openings 14
- Define Natural Ventilation 18
- Edit Lights and Appliances 19
- Edit Heating and Cooling Systems 20
- Edit Hot Water System 23
- Edit Exterior Shadings 24
- Enter Billing History 26
- Create Alternatives 26
- Edit Schedule Items 27
- Set Options 36
- Setup and Run 38
- 3D Viewer 41
- View DOE-2 Files 41
- View Results 43
- View Graphs 45
- Use Library 46
- Custom Block Editor 46
- Project Files 53

Diagnose Results 54

Energy Efficient Measures 59

Technical Support 60

Program Limitations 60

Appendix - HomeEnergy Reports 60

List of Figures

Figure 1 Software components used by HomeEnergy 1
Figure 2 HomeEnergy main form after a house is created 2
Figure 3 Registration Form 6
Figure 4 Online Help Topics 7
Figure 5 Main form before a house is created 8
Figure 6 The General Folder 9
Figure 7 The General Folder in detailed mode 10
Figure 8 The Shape Folder 11
Figure 9 Holidays Editor 12
Figure 10 Define constructions 13
Figure 11 Select constructions for walls, roofs and floors 14
Figure 12 Define openings 15
Figure 13 Define Openings in detailed mode 16
Figure 14 Custom Façade Editor 16
Figure 15 Define natural ventilation 18
Figure 16 Define natural ventilation in S-G method 18
Figure 17 Define Lights and Appliances 19
Figure 18 Edit Lights 19
Figure 19 Edit Major Appliances 20
Figure 20 Edit properties of an appliance 20
Figure 21 Define Heating and Cooling Systems 21
Figure 22 Define Heating and Cooling Systems in detailed mode 22
Figure 23 Define Water Heating System 23
Figure 24 Define Exterior Shadings 24
Figure 25 Enter billing history 26
Figure 26 Define Alternatives 26
Figure 27 Organizer Form 28
Figure 28 Utility Rate Editor 29
Figure 29 Schedule Editor 30
Figure 30 Day Schedule Editor 32
Figure 31 Construction Editor 33
Figure 32 Material Editor 34
Figure 33 Opening Editor 35
Figure 34 Occupancy Editor 36
Figure 35 Color Settings 37
Figure 36 Grid Settings 37
Figure 37 Path to DOE-2 Engine 38
Figure 38 Setup and Run 38
Figure 39 DOE-2 Standard Reports 39
Figure 40 DOE-2 Hourly Reports 40
Figure 41 3D Viewer 41
Figure 42 DOE-2 Files Viewer 42
Figure 43 View Reports Setup 43
Figure 44 HomeEnergy Reports 44
Figure 45 HomeEnergy Graphs 45
Figure 46 Custom Block Editor 46
Figure 47 Energy bill of an average house vs an energy efficient house 59

What is HomeEnergy

Introduction

HomeEnergy is a comprehensive residential energy analysis program that performs a detailed hourly simulation of energy use in houses. HomeEnergy combines the power of DOE-2.1E v110 simulation engine and user-friendly graphical interface to create house models and perform detailed energy calculations. HomeEnergy is developed by Eley Associates through California PIER II funding.

HomeEnergy has matured from several phases including, mockup, alpha version testing, and beta version testing. The software has been significantly improved based on feedback from CEC staff, focus groups, inside and outside testers.

HomeEnergy has two versions, the professional version is for architects and engineers, the lite or owner version is for home owners, school students and those with not much knowledge of building and energy. Both versions share the same foundation software components. User interface for the lite version is pretty simple, it incorporates a wizard to help users describe the house and its service systems. User interface of the professional version enables users to create a house based on some brief inputs, and customize the house in details.

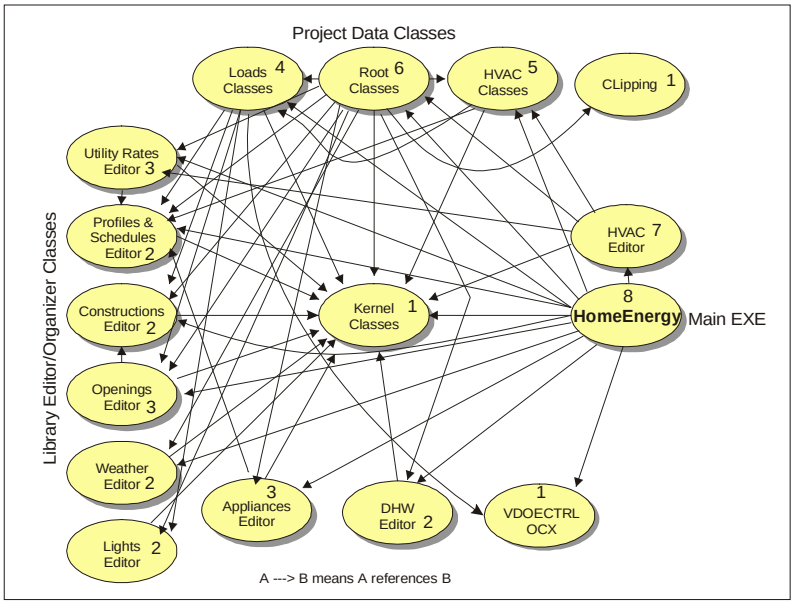
HomeEnergy has been validated by comparing the calculated monthly electricity and gas use with utility bills for two houses in California. Refer to validation report for details.

HomeEnergy can be used to evaluate utility offers and explore energy saving potentials by improvements of wall insulation, windows, natural ventilation, air ducts, heating and cooling systems, lights and appliances, water heating system, etc.

Software Components

HomeEnergy is built upon VisualDOE 3.0 foundation components, its features can be easily extended and improved if necessary. Figure 1 shows software components used by HomeEnergy.

Figure 1 Software components used by HomeEnergy

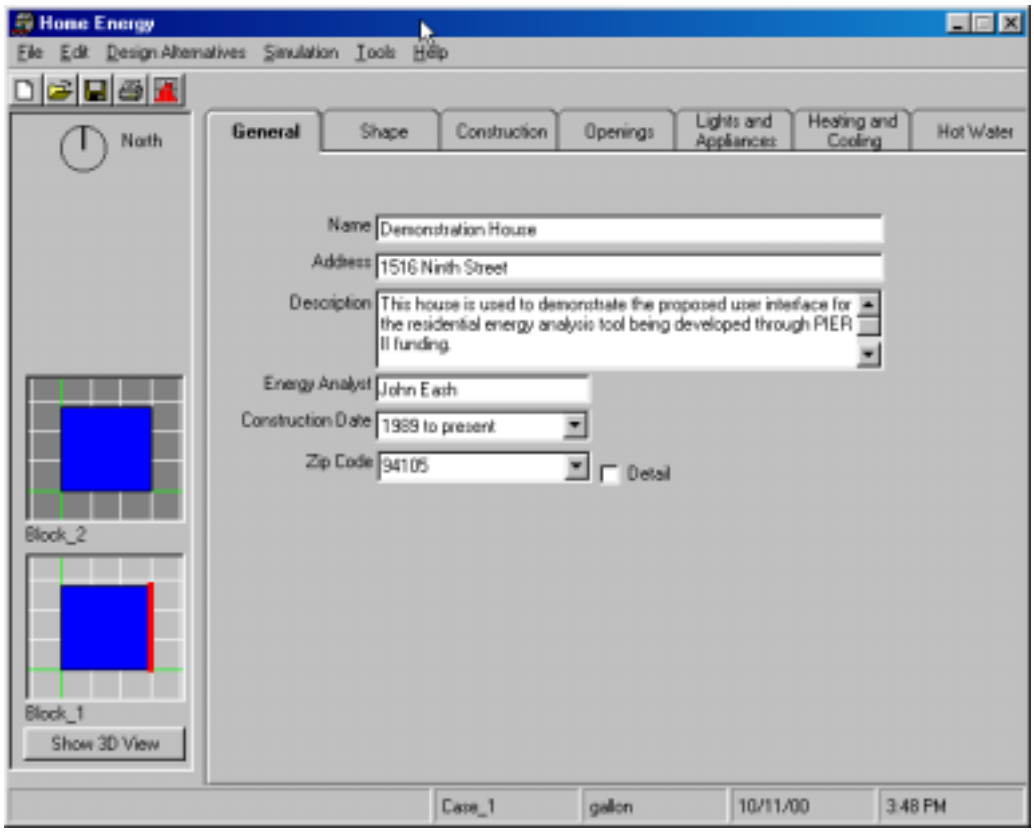


User Interface

Main Form

The main form of HomeEnergy contains a menu bar, a tool bar, a status bar, a plan view port, and folders area.

Figure 2 HomeEnergy main form after a house is created



Menu Structure

The menu bar has six top level menu items, 

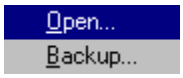
File

New, Open, Save and ***Save As*** are standard file operations.

Recent Used Files List. Click any of the project file list will open it.

Exit. This will close the program. If the project file is changed and not saved, user will be alert to save the file before program closes.

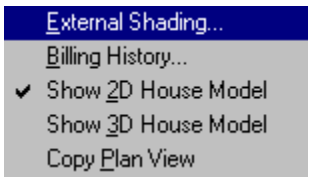
File | Library



Open. This displays a dialogue box for user to select a new database.

Backup. This compresses and creates a copy of the current database.

Edit



External Shading. This shows the Exterior Shade Editor for user to define external shadings of the building.

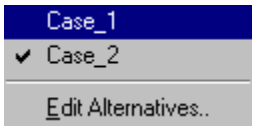
Billing History. This shows the Edit Billing History form for user to enter utility bills.

Show 2D House Model. This turns on/off the panel with plan views of the building.

Show 3D House Model. This shows a form to with the three dimensional view of the building.

Copy Plan View. This copies the plan view of the current floor as a bitmap to clipboard.

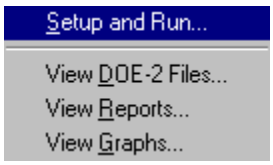
Design Alternatives



Cases List. Click one of the alternative list will make it the current alternative.

Edit Alternatives. This launches the Edit Alternatives form.

Simulation



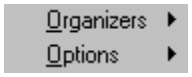
Setup and Run. This launches the Setup and Run form.

View DOE-2 Files. This launches the DOE-2 Files Viewer form.

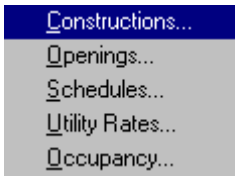
View Reports. This launches the View Reports form.

View Graphs. This launches the View Graphs form.

Tools

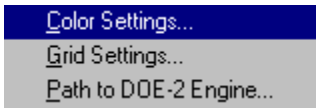


Tools | Organizers



Organizers List. Click any of the list will launch its organizer form.

Tools | Options

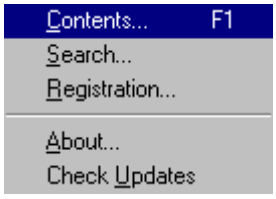


Color Settings. This launches the Color Settings form.

Grid Settings. This launches the Grid Settings form.

Path to DOE-2 Engine. This shows a dialogue box for user to locate the path to DOE-2 engine files.

Help



Contents. This shows the table of content of the help system.

Search. This shows a form to search text from the help file.

Registration. This launches the Registration form for user to register the HomeEnergy program.

About. This shows a form with the version, registration information etc. of the software.

Check Updates. This tells to run GDTLiveUpdate to get latest files for HomeEnergy program.

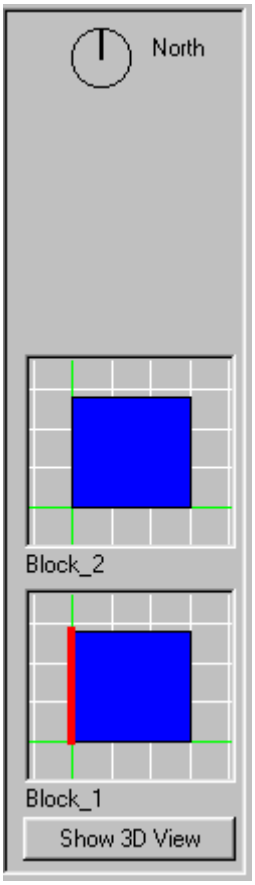
Status Bar

The status bar contains 5 panels displaying the file that is open, the design alternative you are working on, unit of the focused input, along with the current date and time.

Tool Bar

The tool bar provides handy access to File | New, File | Open, File | Save, Simulation | View Reports, and Simulation | View Graphs.

Plan Views



Plan views of the energy simulation model is displayed in the left side of the main form if the Show Details box at the Shape folder is checked. The plan view looks different and performs different functions, depending on the current folder. There are a number of plan view features that are the same, however, no matter which folder is current. These include the following:

- Double click any floor view will launch the custom block editor where user can customize the floor plan.
- Grid lines are displayed on the plan view. To change the grid spacing or to not display the grid spacing, choose menu Tools | Options | Grid Settings from the main form.
- The plan view uses the color settings that you have chosen. To change these, choose menu Tools | Options | Color Settings.

At the Shape Folder, select a floor in the floor List will highlight the floor, select a room/space will also highlight it. At the construction and Openings Folder, the selected façade will be highlighted. At the Heating and Cooling Folder, if the Detail box is checked, selecting a system will highlight all its zones/spaces

For HomeEnergy, the plan view can show up to three floors. Click the Show 3D View button will show the 3D view of the house model. The North Arrow shows the direction of the North. The orientation of the house is the normal of the lower façade in the drawing of the first floor.

System Requirements and Installation

System Requirements

Minimum hardware requirements include a 32 bit x86-based IBM compatible PC, VGA graphics card, color VGA monitor, mouse, 16MB RAM or more, 40MB of available disk space.

Software requirements include Microsoft Windows 95, Windows 98, Windows 2000 or Windows Me.

Install HomeEnergy

HomeEnergy is distributed on a CD-ROM, which includes both versions of HomeEnergy, the DOE-2 simulation engine, California 16 climate zone weather files, and user documents.

If you install any previous version of HomeEnergy software, please uninstall it before you install the new version. Insert the HomeEnergy CD in the CD-ROM drive, the installation will be launched automatically, otherwise, run the setup.exe on the root directory of the HomeEnergy CD. Follow the setup instructions that appear on the screen. Reboot your computer after installation completes. Two shortcuts will be created on your computer desktop, one for the HomeEnergy Professional version, the other for the HomeEnergy Lite/Owner version.

Windows NT and Windows 2000 users have to log on as administrator before installing the program because HomeEnergy program will store some information in the windows registry.

By default, the following directories will be created on your computer,

C:\Program Files\GDT

C:\Program Files\GDT\DOE2

C:\Program Files\GDT\Weather

C:\Program Files\GDT\Shared

C:\Program Files\GDT\Shared\Help

C:\Program Files\GDT\HomeEnergy

HomeEnergy can be uninstalled from the Add/Remove Programs in Control Panel by selecting HomeEnergy and Clicking the Remove button. Most installed files will be removed automatically, but some project files may have to be removed manually.

Run HomeEnergy

Either double click the shortcut/icon on the computer desktop, or go to menu Start | Programs | Green Design Tools to run either version of HomeEnergy.

Using HomeEnergy

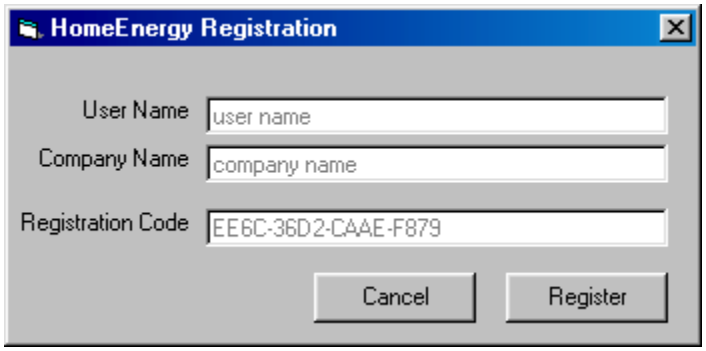
Register Program

HomeEnergy can be run in evaluation mode without registration, but some limits apply,

- Houses of less than 3 floors and 7 rooms can be created
- Only one design alternative can be created
- Only sample project files can be opened
- Reports can be viewed and printed but with “Unregistered User” imprint at the footer. Reports can’t be exported as RTF or PDF.
- A banner message appears each time the program starts

User needs to register the program in order to unlock all features. Registration is done only once. Go to menu Help | Registration to launch the registration form,

Figure 3 Registration Form



Enter user name, company name, and registration code, then click Register button to register the HomeEnergy program. This information should come with the sale receipt of HomeEnergy CD.

Use Online Help

Online help is available any time by pressing the F1 key. The tutorial section is helpful for a quick startup.

Figure 4 Online Help Topics

Perform an Energy Analysis

Performing energy analysis of a house with HomeEnergy includes four steps,

1. Describe the house and its service systems

House geometry and construction, lights and appliances, heating and cooling system, water heating system, schedules, utility rates, vacation, etc.

2. Specify weather file

Select a DOE-2 weather file. For HomeEnergy, the default weather files are the 16 California climate zone weather files. User can select other weather files.

3. Run simulation

Select DOE-2 standard reports and hourly reports before making a DOE-2 simulation. For HomeEnergy, the simulation period is from Jan. 1 to Dec. 31. DOE-2 runs will be displayed in a DOS window.

4. Review results

After the simulation, HomeEnergy provides reports and graphics of the calculation results. If the utility bills are input, user can also compare the bill with calculation results.

Simulating the energy performance of buildings is a complex process. HomeEnergy makes it easy for you to create a DOE-2 input file and to perform simulations. It does not, however, guarantee reliable results. Care must be taken to evaluate the simulation output files to assure that the results are valid. It is important that you carefully review the results of your simulation before making decisions.

- The most basic way to review and evaluate your results is to look at the HomeEnergy reports. These reports contain a summary of information you entered and a summary of the results.
- You may also want to look at one or more of the DOE-2 reports. These are produced by DOE-2 following each successful simulation.
- If your simulation failed, you should review the project LOG file. This file is named MyJob.LOG where “MyJob” is the project file name you have assigned. This file is located in the same directory as MyJob.hes, etc. This file includes a listing of problems that may have occurred when attempting to create the DOE-2 input file.
- Finally you may want to look at the BDL files. These files report problems that DOE-2 discovered with the input file.

Create a House

The first step to make an energy simulation is to create the house model. Figure 5 shows the main form after HomeEnergy program is loaded. User can open an existing project file and edit properties (Figure 2). To create a new house, user first enters data on the General Folder (Figure 6 and 7) and the Shape Folder (Figure 8), and then clicks the Auto Build button on the Shape Folder. Figure 2 shows the main form after a house is created. Table 1 shows rules used in auto building a house shape. After auto building the house model, its floor plans can be customized in Custom Block Editor.

After a house has been auto built, user can modify data on other folders without clicking the Auto Build button again.

Figure 5 Main form before a house is created

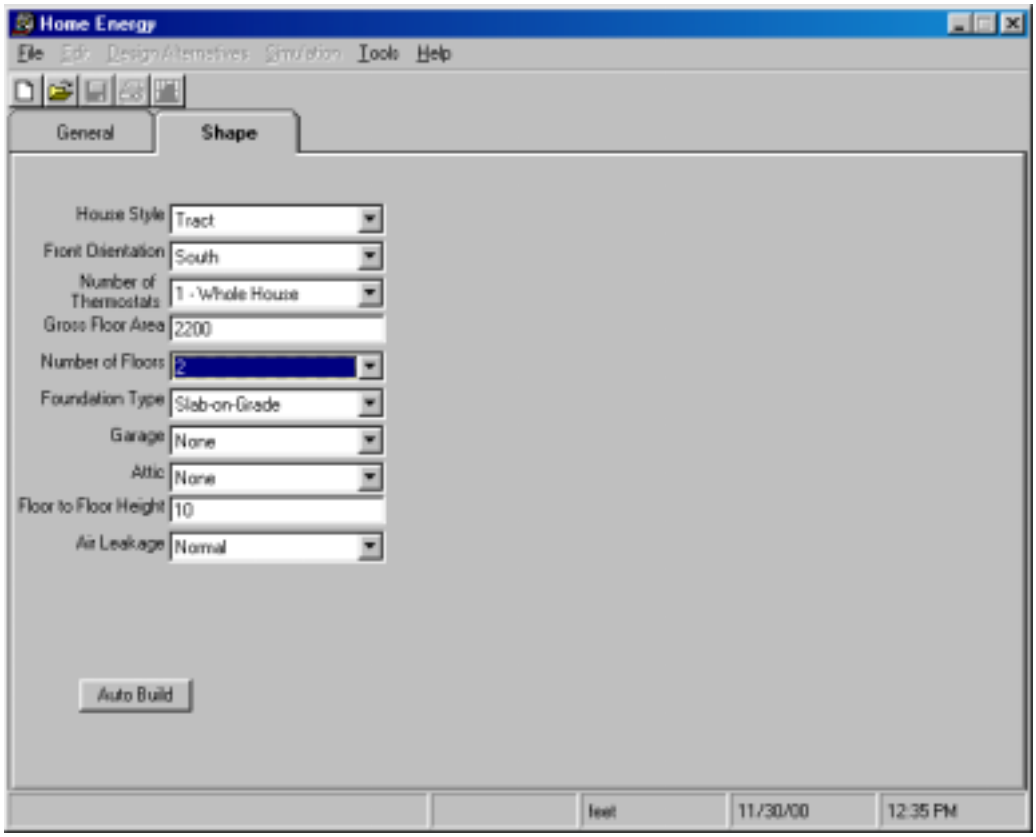
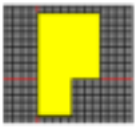
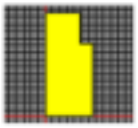
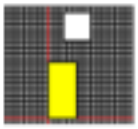
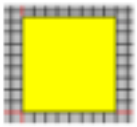
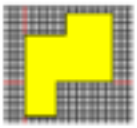
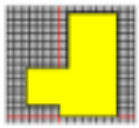
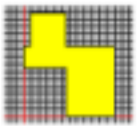
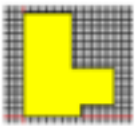
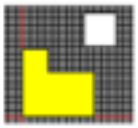
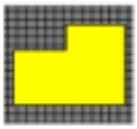
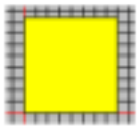


Table 1 Rules used in auto building a house

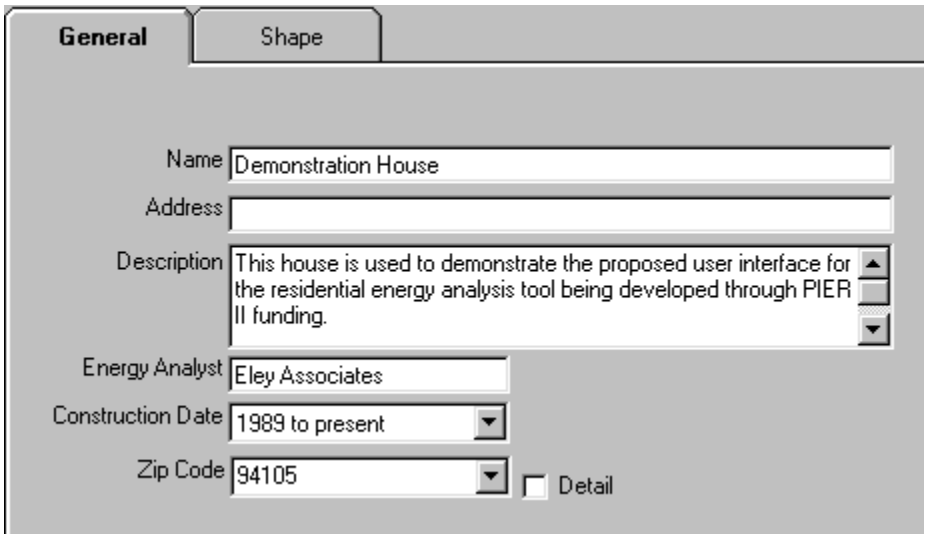
Rules used in auto building a house

Style	Area (ft2)	Floors	Lot Width	Cars	Garage: Front	Left	Back	Right	Detached	None
Tract	0-1500	1	40	1	 W=LW-10 D=A/(W*F)	N.A.	 W=LW-17 D=A/(W*F)	N.A.		
		2	40	1						
		3	30	1						
	1501-3000	1	50	2						
		2	40	2						
		3	40	2						
	3001-5000	1	60	2						
		2	50	2						
		3	40	2						
	> 5000	1	70	3						
		2	60	3						
		3	50	3						
Ranch	0-1500	1	60	1	 "L" shape only if A/(W*F)≥LW-10					
		2	50	1						
		3	40	1						
	1501-3000	1	70	2						
		2	60	2						
		3	50	2						
	3001-5000	1	80	2						
		2	70	2						
		3	60	2						
	> 5000	1	90	3						
		2	80	3						
		3	70	3						
Townhouse Duplex and Apartment	0-1500	1	22	0	☐Party Wall Left ☐Party Wall Right ☐Top Floor ☐Bottom Floor units always have front and back exposure					
		2	20	0						
		3	18	0						
	1501-3000	1	28	0						
		2	24	0						
		3	20	0						
	3001-5000	1	34	0						
		2	30	0						
		3	26	0						
	> 5000	1	40	0						
		2	36	0						
		3	32	0						

Where, A is the total floor area, W is the width of the house, LW is the lot width, D is the depth of the house, and F is the number of floors.
Depth of the garage is assumed of 24 feet, width depends upon the number of cars, for a one, two and three cars garage, the width will be 12, 22, and 33 feet respectively.

The General Folder

Figure 6 The General Folder

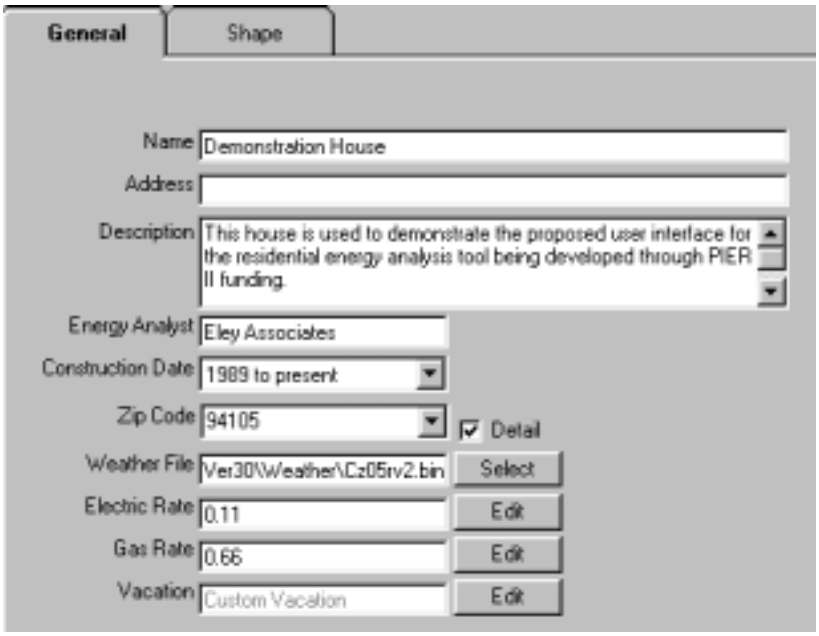


Name|Address|Description. The general folder is where you enter a name for your house, its address, a description, and your name (you are the energy analyst). This information is optional and does not affect the calculations. However, if you use the program for more than one house, it will help you keep track of each project.

Construction Date. Choose a period during which the house was constructed. If the house was substantially remodeled, then enter the date of the remodel. The date is one of the factors taken into account when Home Energy makes assumptions about the thermal performance and the type of equipment in your house. These assumptions are defaults, which means that you can override the assumptions later if you have better information.

Zip Code. Enter the zip code where your house is located. The program will select weather data and typical utility rates to use in the energy analysis. If you click the *Detail* checkbox, the assumptions will be displayed for you and you can modify the default information.

Figure 7 The General Folder in detailed mode



Weather File. This shows the weather file to be used by the DOE-2 program. User can enter the weather file name here or click Select button to locate a weather file. The default weather data is California climate zone based on the zip code user inputs.

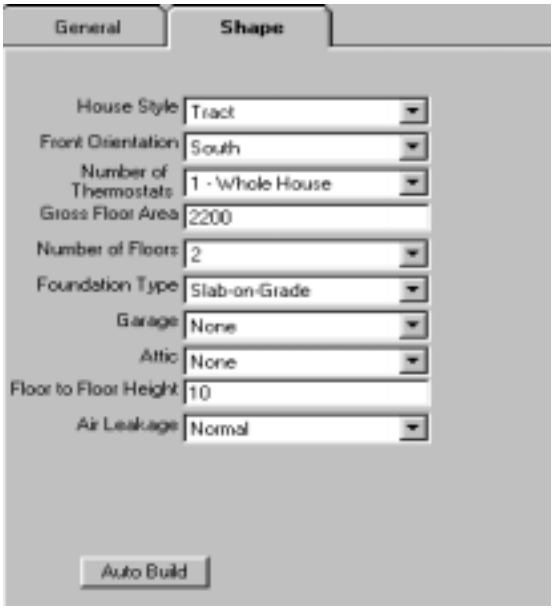
Electric Rate. Enter the electricity rate you pay or click Edit button to launch the Utility Rate Editor to define a more detailed electric rate.

Gas Rate. Enter the gas rate you pay or click Edit button to launch the Utility Rate Editor to define a more detailed gas rate.

Vacation. Click the Edit button to launch the Holidays Editor.

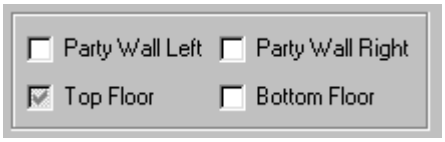
The Shape Folder

Figure 8 The Shape Folder



Most building shape data is specified at the folder. The following describes the information requested and give you some suggestions about what to enter. In most cases, providing requested information is a matter of choosing something from several options.

House Style. Choose the style that best represents your house. If you live in a single-family home, you should choose either *Tract* or *Ranch*. A *Tract* house is built on a smaller lot and usually has a garage across much of the front of the house. Choose *Ranch* if your house is on a larger lot and has a more rambling floor plan. The other choices are *Townhouse*, *Duplex*, and *Apartment*, which are self-explanatory. You can also choose *Custom*. This allows you to customize the floor plan of your house in Custom Block Editor. If house style is *Townhouse*, *Duplex*, or *Apartment*, user also need to check if the house has party walls, is on the top floor or bottom floor.



Front Orientation. Pick the *Orientation* for the front of your house. The choices are *north*, *northeast*, *east*, etc.

Number of Thermostats. Choose *1- Whole House* if have just one thermostat. Some larger houses have a separate heating and/or cooling system for the bedrooms, if this is the case, choose *2-Separate Living/Sleeping*.

Gross Floor Area. Enter the floor area of your house. Do not count the floor area of the garage, unconditioned basements, attics, adjacent sheds that are not heated. When HomeEnergy auto builds the house, each floor area will equal the Gross Floor Area dividing the number of floors.

Number of Floors. Enter the *Number of Floors* for your house. If you have a split-level house, enter the number of stories for the portion with the maximum number of floors.

Foundation Type. Choose the type of *Foundation* for your house. The choices are *Slab-on-Grade*, *Ventilated Crawlspace*, *Unventilated Crawlspace*, *Conditioned Basement* and *Unconditioned Basement*. California homes on flat land are typically constructed on slab-on-grade. Homes on hillside lots typically have an unconditioned crawlspace. An unventilated crawlspace is fairly unusual and typically has insulation installed on the side walls of the crawlspace rather than under the floor.

Garage. Choose the location of the garage or select *None* if your house does not have a garage.

Attic. If your house has an *Attic* then choose either *Gabel Roof* or *Hip Roof*. A gabel roof slopes in just two directions while a hip roof slopes to the walls in all directions.

Floor-to-Floor Height. Enter the *Floor-to-Floor* height in feet. A value of 9 feet is appropriate for houses that have a floor-to-ceiling height of 8 feet.

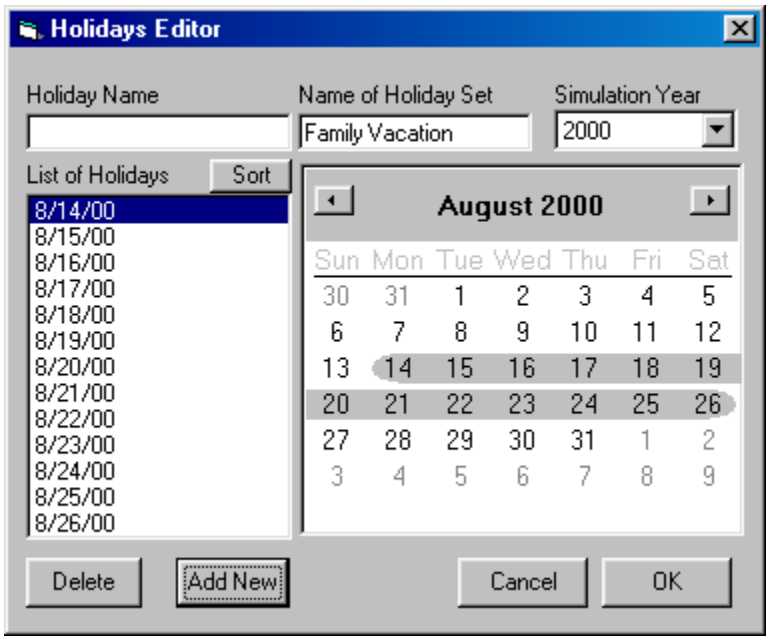
Air Leakage. Choose the Air Leakage of the house. The choices are Loose, Normal and Tight.

Figure 2 shows the house model after user enters data on the general folder and the shape folder, clicks the Auto Build button on the shape folder, and check the Detail box on the shape folder.

Define Vacation

Family vacation can be defined in the Holidays Editor launched from the General Folder. For HomeEnergy program, the holidays are those days when the family is on vacation.

Figure 9 Holidays Editor



Add New. This button adds the date that is selected in the calendar to the list of holidays to be observed.

Delete. This button removes the selected holiday from the list of holidays. Hint, you can select more than one holiday delete them all at once.

Simulation Year. The simulation year must be defined in order to define the holidays. This can be any year you want, but your choice of holidays should be selected for the year, e.g. you do not want to observe holidays on a Sunday.

Calendar. This control is used to select days to be added to the list of holidays. Use the right and left arrows at the top to move from month to month. To add a holiday to the schedule, select the date and then click the Add New button.

Name of Holiday Set. Enter the name that you want to assign to the holiday set.

Holiday Name. Enter the name you want to give to each holiday that is observed.

Sort. This sorts the holidays in the List of Holidays.***OK***. This button saves your changes and leaves the form.

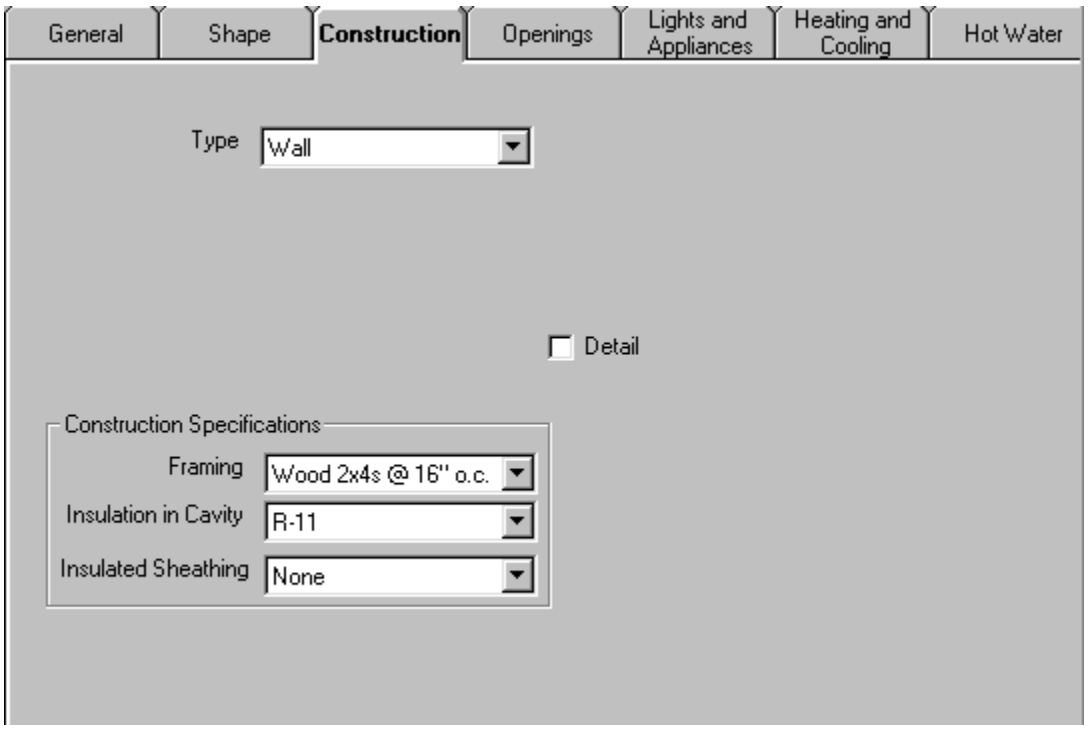
Cancel. This button abandons your changes and leaves the form.

Define Constructions

After a house is created, user can specify how the house is constructed and how it is insulated.

In simple mode (the Detail box is not checked), all walls are assumed to be of the same construction, so are roofs and floors.

Figure 10 Define constructions



Type. Select a construction type to specify by selecting either *Wall*, *Roof*, or *Floor* in the *Type* drop down list box. The screen capture to the right has *Wall* selected. You can then specify three properties for your walls:

- the type of framing
- the insulation that is installed in the cavity
- any insulation that may be installed in a continuous manner

Framing. The type of framing is important since cavity insulation is penetrated by the framing. Metal framing (which is fairly uncommon in residences) is highly conductive. As a result, heat loss through metal framing is much higher than through wood framing. The thickness and spacing of the framing is also important. Common framing choices are displayed for you to choose from. Wood 2x4s @ 16” o. c. is the most common construction for California homes.

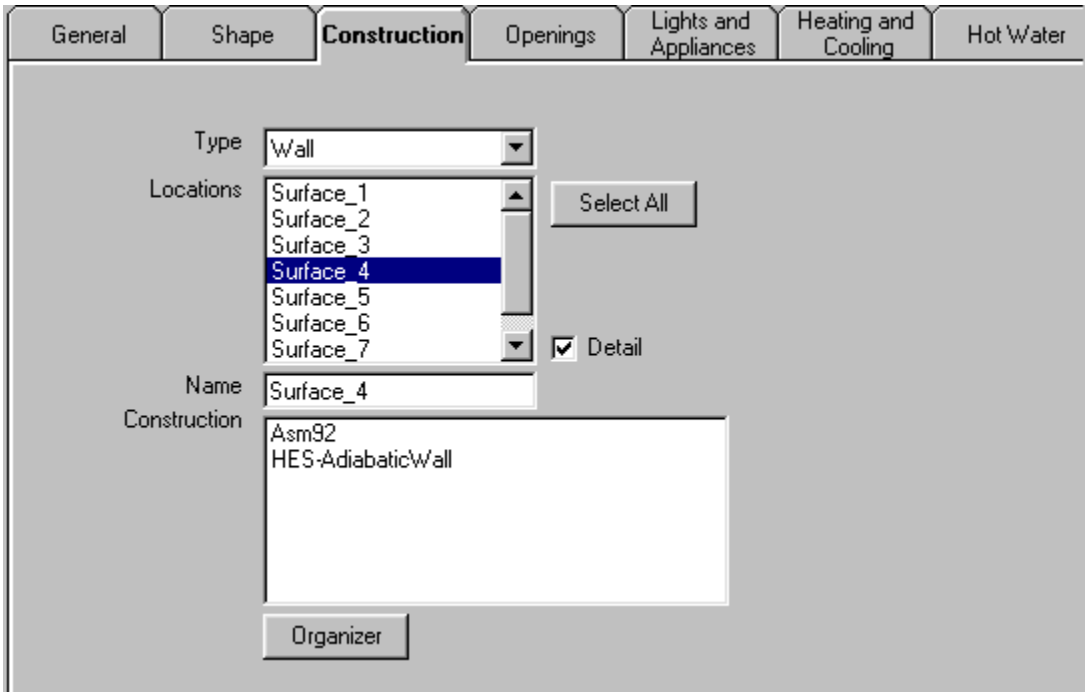
Insulation in Cavity. The cavity is the space between the wall framing members. Choose the insulation level for this cavity. The choices that are displayed depend on the framing thickness you previously selected. For 2x4s, the only choices are *None*, *R-11* insulation, and *R-13* insulation.

Insulated Sheathing. Finally you select the *Insulated Sheathing*. For most homes you will select *None*. However, some recently constructed homes in the central valley or in the mountains may have a rigid insulation installed as sheathing. The rigid insulation is typically blue in color, but covered by the exterior finish. The interior and exterior finish are not very important as far as heat loss is concerned so those choices are not available to you. Instead, a reasonable assumption is made.

The process is similar for *Roof* and *Floor*, except that some of the choices are different. For roofs and floors, the insulated sheathing is eliminated as an option since its installation is not a common practice.

If the house has more than one construction type for walls, or the construction cannot be modeled in the form of framing, insulation in cavity, and insulated sheathing, user can define constructions in detail mode by checking the Detail box.

Figure 11 Select constructions for walls, roofs and floors



Name. The name of the façade can be changed.

Select All. This selects all walls.

Construction List. This list box contains all appropriate constructions that can be assigned to facades.

Organizer. Click this button to add more constructions to the Construction list.

The process to assign a construction to one or more facades is as follows,

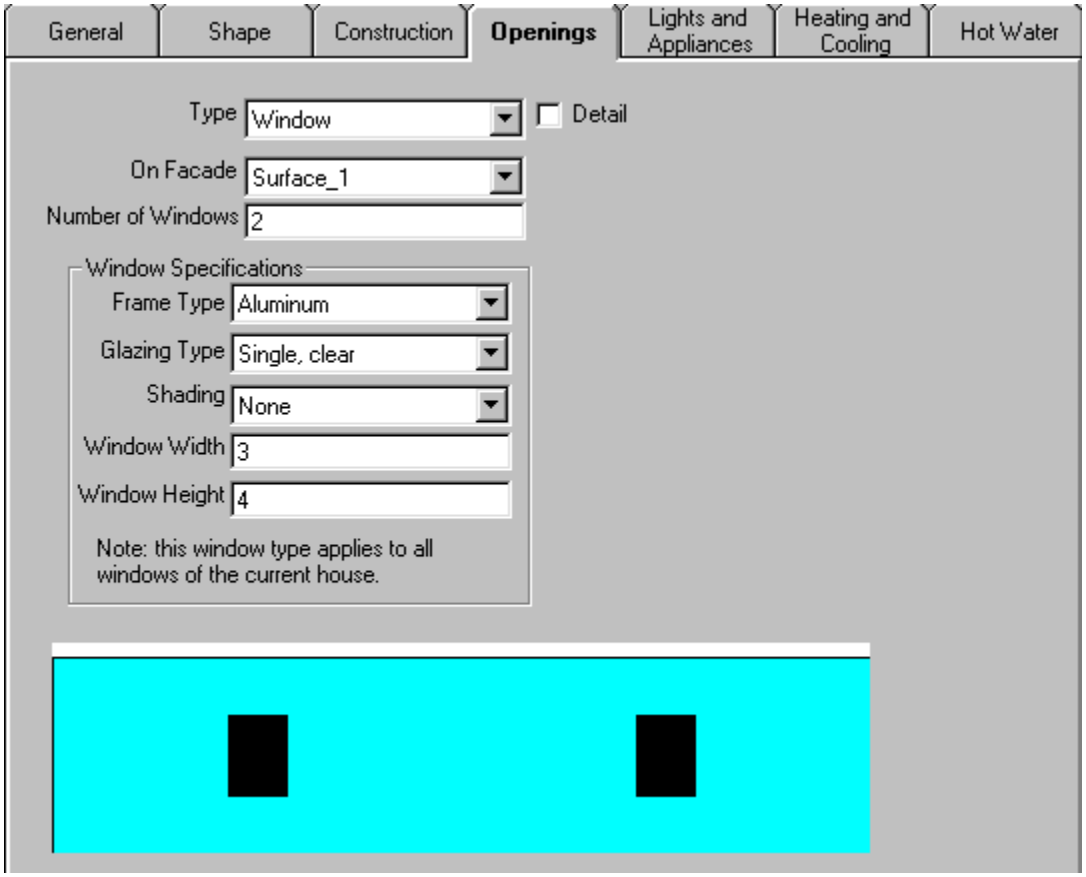
1. Specify the type of construction, either Wall, Roof or Floor
2. Select one or more facades in the locations list
3. Select a construction in the construction list

Define Openings

The *Openings* tab is where you specify information about your windows and skylights. On this tab, you can specify the properties of your windows separately for each side of the house and for each floor of the house. Before you start, go to the *Shape* tab and click the *Show Details* button. This will cause some small diagrams of the floors in your house to appear on the left side of the form. The lower portion shows the façade and its windows.

In simple mode, there is only one type of windows for all walls and one type of skylight for all roofs. Figure 12 shows the interface to define windows.

Figure 12 Define openings



Type. Select the type of opening, either window or skylight.

On Façade. Select the façade where openings will be edited. When you select a surface, it is highlighted on the plans so you can tell which side of the building you are defining the windows for.

Number of Windows. Enter the number of windows for the selected façade.

Frame Type. The choices are *Aluminum*, *Aluminum with Thermal Break*, and *Wood/Vinyl*. The *Wood/Vinyl* choice should be used for any window that is non-metallic, including fiberglass. Unless you have detailed information about your house it will be hard to tell if aluminum windows have a thermal break. The best thing to assume is that they do not.

Glazing Type. *Glazing Type* choices are based on the number of panes, type of glass (tinted/ clear) and, and type of coating on the glass (solar-control low-e/ insulating low-e).

Shading. Choose the appropriate shading from the list of interior and exterior shadings.

Window Width. Enter the window width.

Window Height. Enter the window height.

In detailed mode (the Detail box is checked), user can specify each window separately for each wall. Windows can be imported from the library. Click the Edit Openings button to launch the custom façade editor to define windows on a façade.

Figure 13 Define Openings in detailed mode

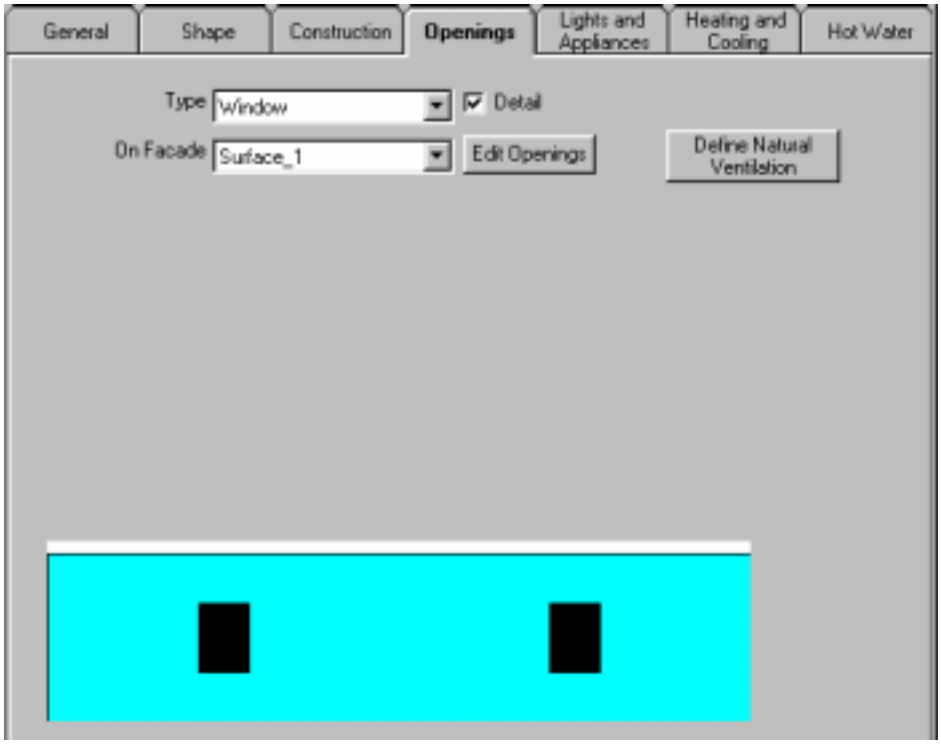
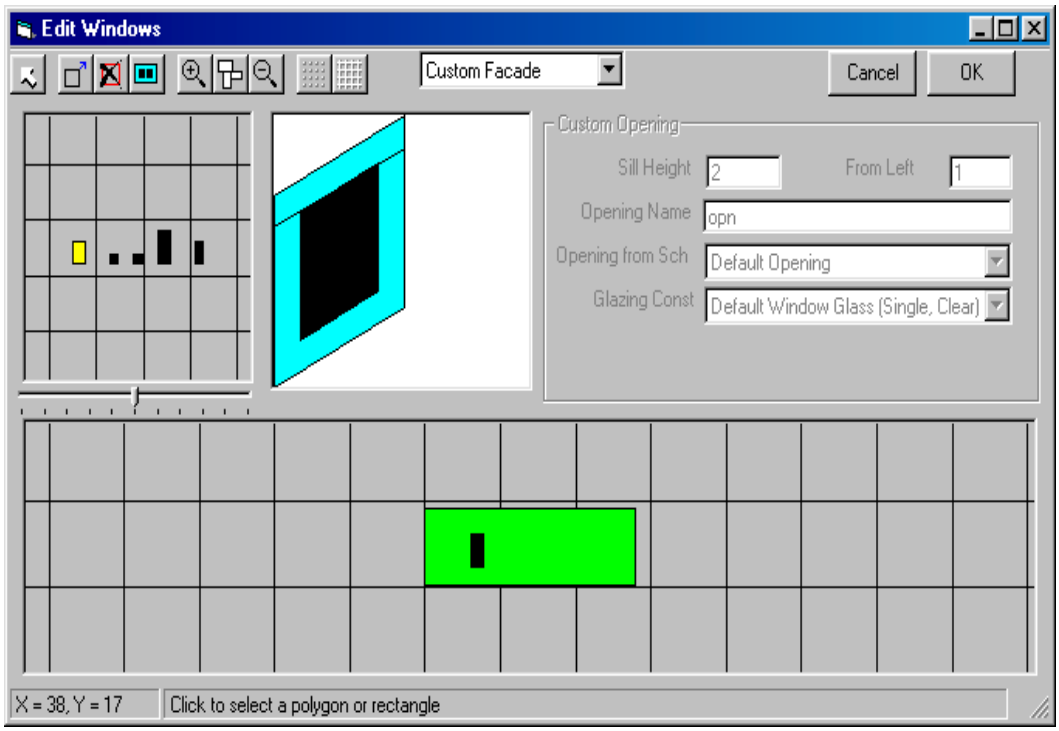


Figure 14 Custom Façade Editor



The custom façade editor is used to place and position openings on an exterior façade or over a room. It is also used to set the properties of each of the openings. It is only used for custom facades and skylights. The openings editor looks a little different depending on whether you are editing windows in a façade or skylights over a room. However, the editing process is exactly the same. If you are editing a façade, an elevation view

of the façade is displayed showing the size and position of the current openings. If you are editing skylights, an outline of the room appears with the size and position of the skylights shown.

The upper left view shows all openings user can assign to your house. Double Click one of them to select it, its drawings will be shown in the upper middle view and properties shown in the upper right frame. If there are more openings to be fit in the upper left viewport, use the scroll bar to view and select other openings.

User can drag and drop an opening from the upper left view to the lower façade view.

Tool Bar

Select. Use this tool to select a single opening. When you select an opening, its properties are displayed. These properties of the selected window can then be edited. For each opening you can edit the sill height, the distance from the left side of the wall/surface, the opening object and the glazing.

***Select All*.** Select all openings on the façade.

Move Opening. Use this tool to reposition an opening by dragging it to a new location with the mouse.

Delete Opening. Use this tool to delete the selected opening from the façade or surface.

Refresh Drawing. This tool refreshes the view of the façade/room. Usually the view is automatically refreshed.

Zoom In. Use this tool to zoom in on a portion of the façade/room. Drag the mouse pointer over the area that you want to zoom to and release the button.

Zoom Out. This tool zooms out to the previous view. If there are no previous views, then one grid spacing is added in each direction.

Zoom Extents. This tool zooms so that the extents of the façade/room is wholly contained within the visible drawing space.

Display Grid. This toolbar button toggles display of the grid lines.

Grid Setup. This toolbar button opens the Grid Settings form. Use this tool to change the snap to grid

Specification Method. Select one of the two choices, Custom Façade and No Openings, in the combo box.

OK. Click this button to save changes made and close the form.

Cancel. Click this button to discard any changes made and close the form.

Define Natural Ventilation

Natural ventilation can be defined at the Heating and Cooling Folder in Detail mode by clicking the Define Natural Ventilation button.

Figure 15 Define natural ventilation

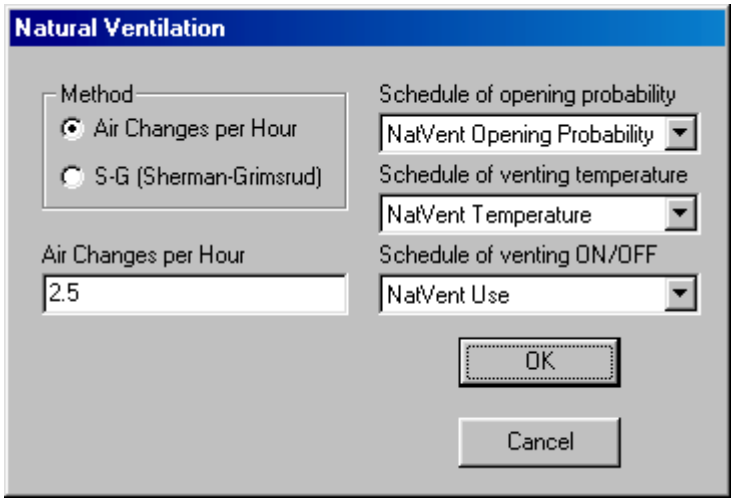
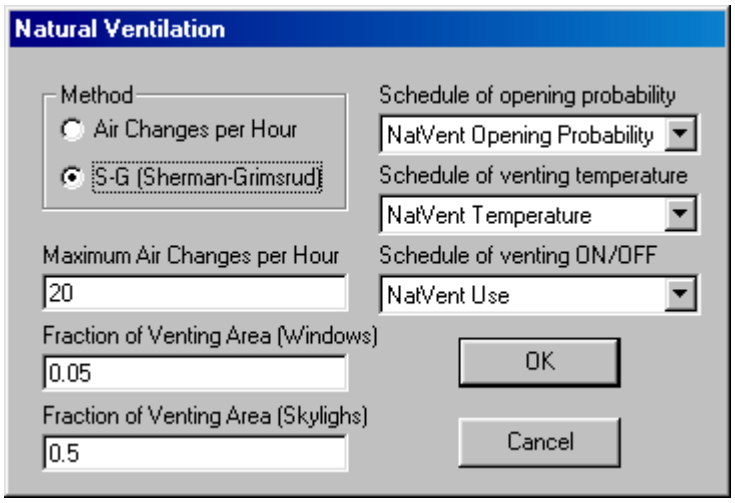


Figure 16 Define natural ventilation in S-G method



Method. Select one of the two methods. If S-G method is selected, the form shows more data entries.

Air Changes per Hour. This is the maximum air changes per hour based on the Outside Air schedule.

Maximum Air Changes per Hour. This only applies to S-G method.

Fraction of Venting Area. Enter the fractions of windows and skylights related to ventilation.

Schedule of opening probability. This schedule defines when the opening can be opened.

Schedule of venting temperature. This schedule defines temperatures that control the ventilation on/off.

Schedule of venting ON/OFF. This schedule defines when the ventilation is on/off.

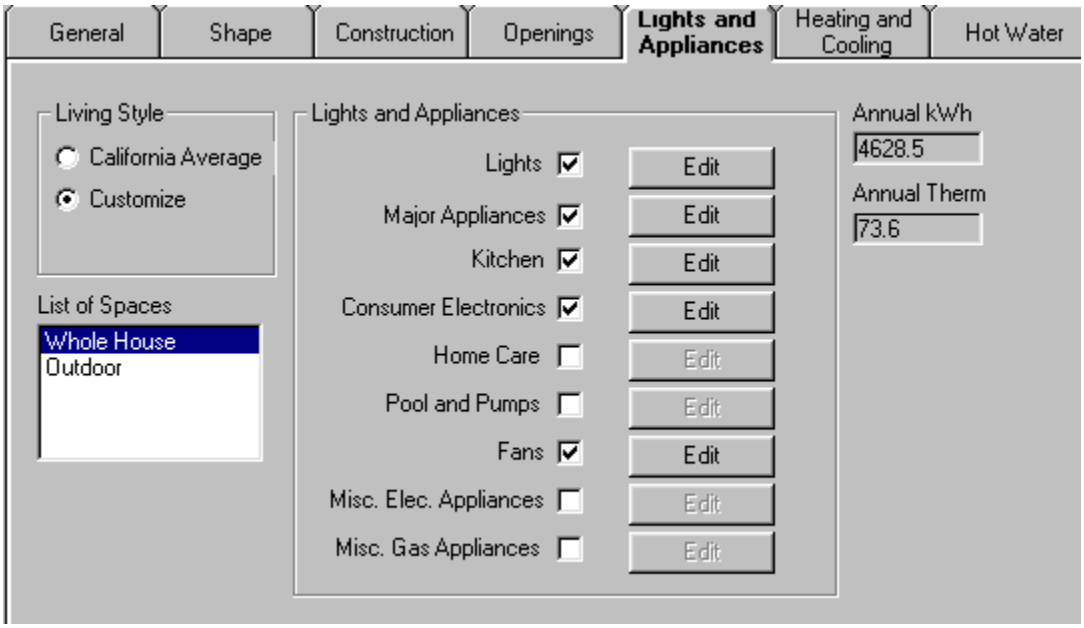
OK. Click this button to save data and close the form.

Cancel Click this button to discard changes and close the form.

Edit Lights and Appliances

Lights and Appliances tab allows user to define lights and appliances of the house.

Figure 17 Define Lights and Appliances



At the simplest level you only need to choose a *Living-Style* option to specify your lights and appliances. One choice is *California Average*. The other option is to choose *Customize*. When you make this selection, controls that allow you to specify details for lights, major appliances, kitchen appliances, consumer electronics, home care products, swimming pools and spas, fans, along with miscellaneous gas and electric appliances are displayed.

When you click the edit button for *Major Appliances*, a form like the following will appear where you can indicate whether or not you have the listed appliance in your house. You may *Edit* the properties of a given appliance or you may *Add* or *Delete* appliances to the existing list. Select the box means you have the appliances in your house. All the items listed under *Lights and Appliances* may be modified in a similar manner.

Figure 18 Edit Lights

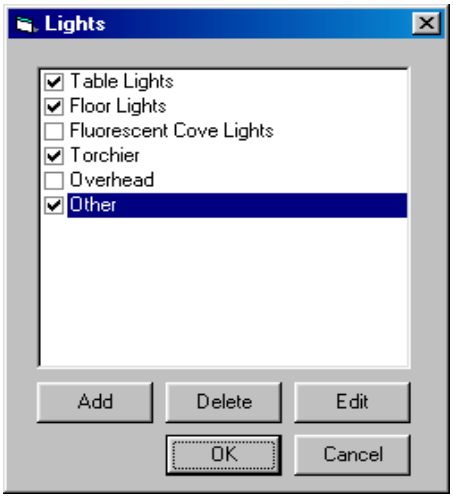


Figure 19 Edit Major Appliances

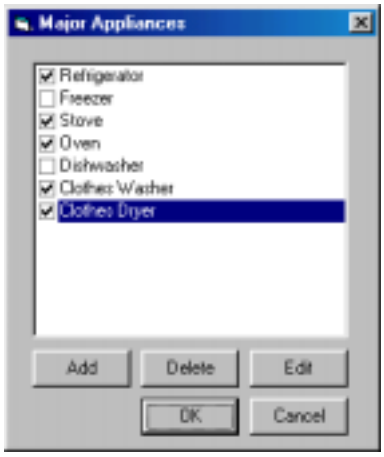
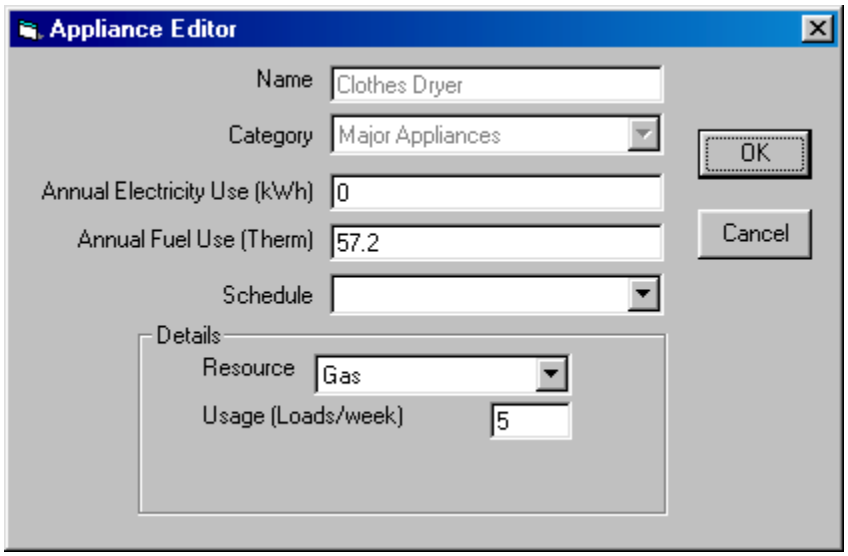


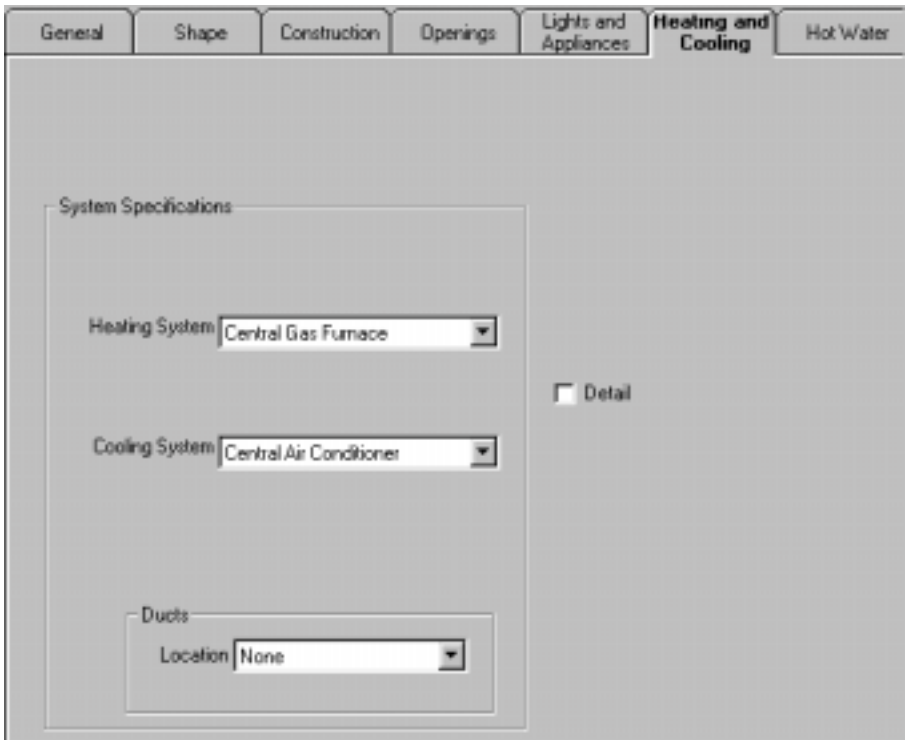
Figure 20 Edit properties of an appliance



Edit Heating and Cooling Systems

The *Heating and Cooling* tab is where you specify information about the heating and cooling systems. In the simple mode, only heating system type, cooling system type, and duct location need to be specified. In the detailed mode, depending on what you choose for Number of Thermostats on the *Shape* tab, either one or two systems will be displayed in the *List of Heating and/or Cooling Systems* list box.

Figure 21 Define Heating and Cooling Systems



System Specifications. Specifications for the selected system are displayed in the *System Specifications* box. Here you can edit the *Name* of the system. You can also choose a *Schedule* for heating and cooling. This is the pattern of thermostat settings for your house. For now, continue to use the default.

Heating System. Choose the heating system type. If the house is not heated, choose None.

Cooling System. Choose the cooling system type. If the house is not air conditioned, choose *None*.

Ducts. If you have air duct for the heating or cooling system, select the duct location and indicate if the ducts are insulated and/or sealed.

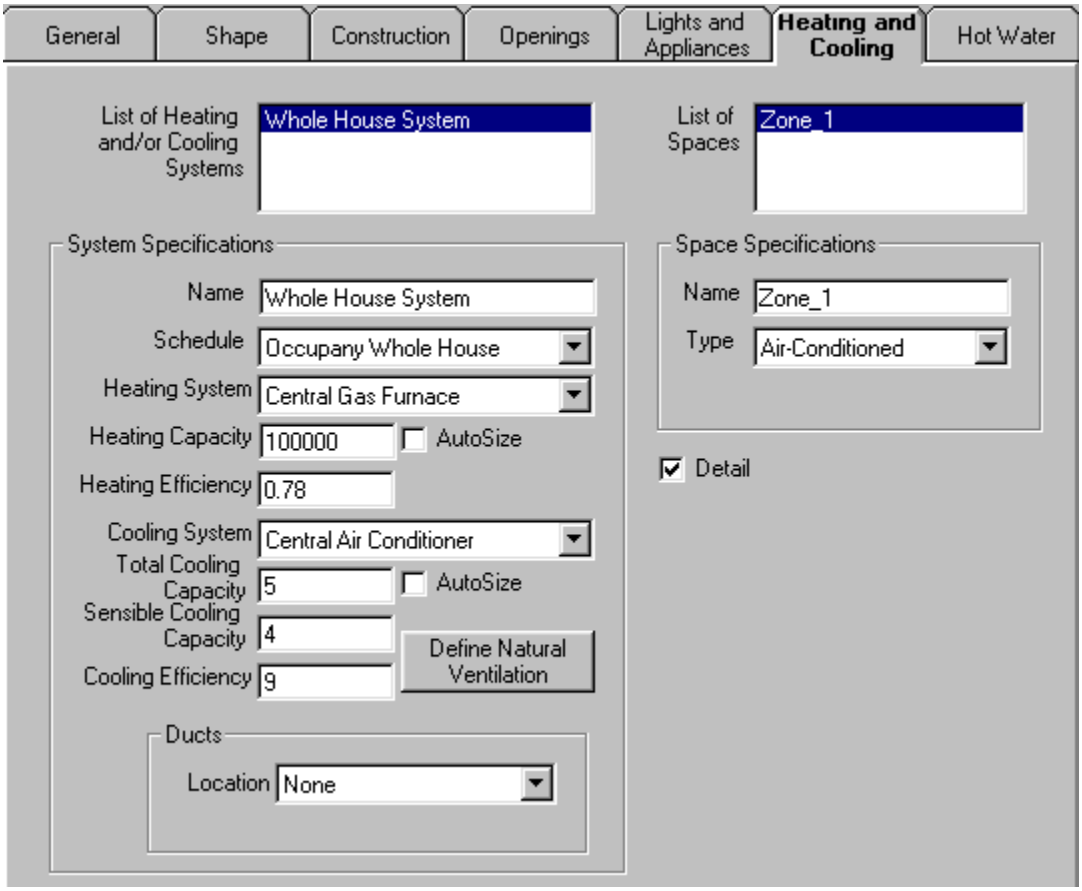
In HomeEnergy, modeling of air ducts is simplified as a correction factor on the heating/cooling system efficiency. The Heating/Cooling system efficiency = (Heating/Cooling equipment efficiency) x (Air Ducts correction factor)

Table 2 Air ducts correction factor on heating/cooling system efficiency

Air Ducts	Correction Factor
None	1.0
Insulated, sealed	0.90
Insulated, not sealed	0.80
Not insulated, sealed	0.85
Not insulated, not sealed	0.75

When the Detail box is checked, user can enter more data for heating and cooling systems of the house.

Figure 22 Define Heating and Cooling Systems in detailed mode



List of Heating and/or Cooling Systems. This list contains all heating or cooling systems of the house you defined. Select one from the list will show its zone list and detailed specifications of the system and zones.

List of Spaces. This shows all zones/spaces of the selected system. Select one the zone/space will show its specifications. User can change the name of the space/zone and set the zone to be air-conditioned or unconditioned.

System Specifications. Name of the system can be changed. Select the system schedule that contains schedules of occupants, lighting, equipment, infiltration, heating temperature, cooling temperature, etc. User can edit these schedules by selecting menu Tools | Organizers | Occupancy.

Heating System AutoSize. If you know the size of the heating system you can enter this information by deselecting *AutoSize*. If you do not know the size, then check *AutoSize* and the program will make the heating system just big enough to meet the maximum heating load during the year. The *Heating Efficiency* will be default value. For gas furnaces and boilers, the efficiency is the ratio of the heat delivered to the house to the energy used by the equipment. Typical values are between 0.60 and 0.90. For heat pumps, the efficiency should range between about 2.5 and 4.0. For electric baseboard heaters, the efficiency will always be about 1.0.

Define Natural Ventilation. Click this button to launch the natural ventilation form.

Table 3 Heating system and default equipment efficiency

System Type	Efficiency (Unit)
None	N/A
Central Gas Furnace	78% AFUE
Room Gas Furnace	78% ET
Propane (LPG) Furnace	78% AFUE
Oil Furnace	78% AFUE
Electric Furnace	100%
Electric Heat Pump	2.9-0.000026CAP COP
Electric Baseboard Heater	100%
Gas Boiler	80% AFUE
Oil Boiler	83% EC

Where, EC is combustion efficiency, CAP is capacity in Btu/hr, ET is thermal efficiency.

Cooling System AutoSize. If you know the size of the cooling system (total capacity and sensible capacity in tons), enter these data, otherwise you can select *AutoSize*, and the program will make the equipment just large enough to meet the maximum cooling load. The *Cooling Efficiency* is expressed as an EER (Energy Efficiency Ratio) and will range between about 7 for old inefficient systems to as high as 14 for new efficient equipment.

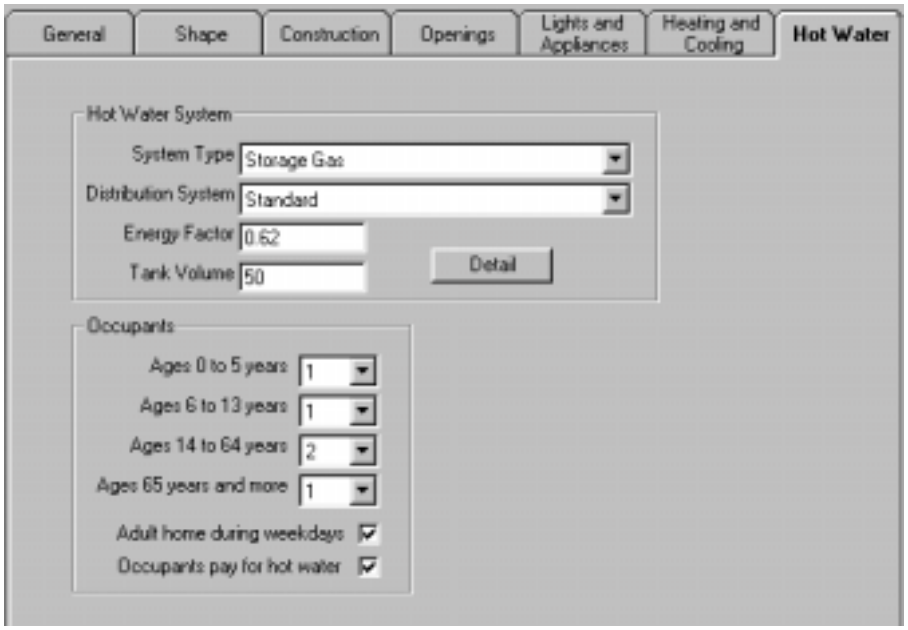
Table 4 Cooling system and default equipment efficiency

System Type	Efficiency (Unit)
None	N/A
Central Air Conditioner	9 EER
Room Air Conditioner	8 EER
Electric Heat Pump	10-0.00016CAP EER

Edit Hot Water System

The *Hot Water* tab is where you give the program information about your water heating system. Information is organized in two categories- *Hot Water System* and *Occupants*.

Figure 23 Define Water Heating System



Hot Water System. This is where you specify the equipment. The most common *System Types* are *Storage Gas* and *Storage Electricity*. These are the typical gas and electric water heaters used in most homes. Most homes also have a *Standard Distribution System*, the other systems being far less common. The *Tank Volume* is the size of the storage tank in gallons. The *Energy Factor* is the efficiency of the water heater, Table 4 shows default values used by HomeEnergy. If you have a recently installed hot water system, the energy factor will be displayed on the big yellow removable label.

Occupants. The number of occupants in each age category is used to determine the amount of hot water that is used each day.

Adult home during weekdays. Check this box if there are adults home during weekdays in the house.

Occupants pay for hot water. This is appropriate for apartment type buildings.

Table 5 Water heating system and default energy factor

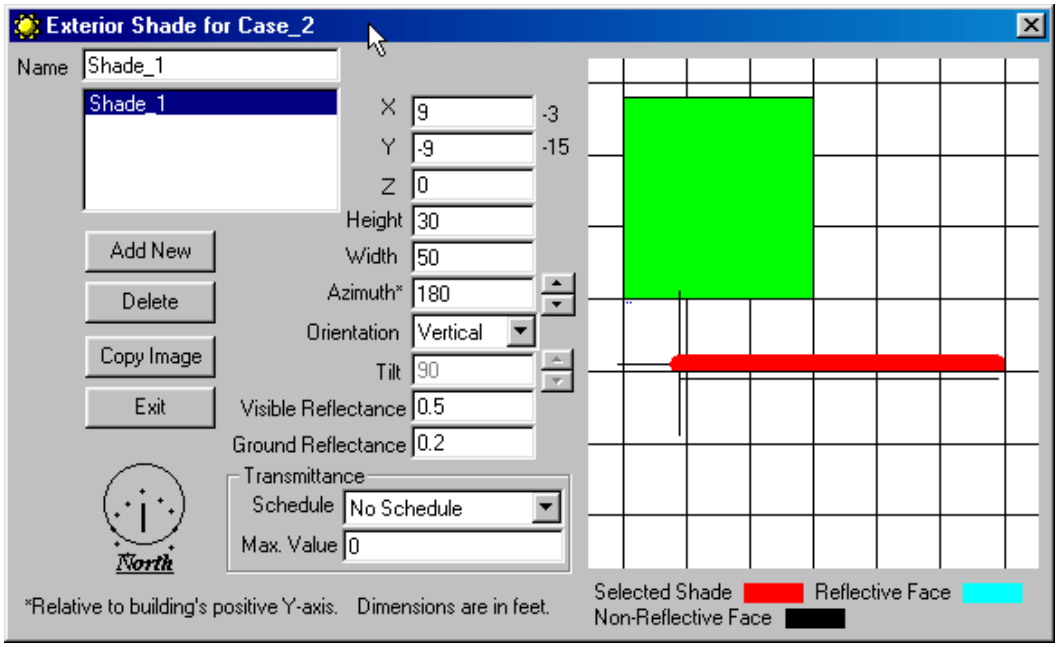
System Type	Energy Factor (Unit)
None	N/A
Storage Gas	0.62-0.0019V (EF)
Large Storage Gas	78% (ET)
Storage Electric	0.93-0.00132V (EF)
Instant Gas	80% (ET)
Instant Electric	0.93 (EF)
Storage Heat Pump	0.93-0.00132V (EF)
Indirect Gas	0.62-0.0019V (EF)
Boiler	77% (ET)

Where, V is the tank volume in gallons, EF is energy factor, and ET is thermal efficiency.

Edit Exterior Shadings

You may enter any number of exterior shades for the simulation of adjacent buildings, trees, or land masses. The Exterior Shading form displays a footprint of your model and shows the size and position of shades as they are entered.

Figure 24 Define Exterior Shadings



To enter an exterior shade, click the Add New button. A new shading surface will be added to the list box and shown on the drawing with default properties. Use the controls to the right of the list box to modify the properties of the selected exterior shade.

Exterior shades are specific to the current design alternative. To enter exterior shades for another design alternative, select that design alternative before you choose Edit | External Shading. Exterior shades in DOE-2 cast a shadow no matter which way they face. However, if you want to accurately model sunlight bouncing off an adjacent building, you must correctly position the reflective surface toward the model. Only one side on an exterior shade is reflective.

The following is a list of the properties that can be defined for each exterior shade.

***X, Y, Z*.** Enter the coordinates of the lower left corner of the shading surface. As you change the coordinates you can see the position of the shade move on the diagram. The lower left corner is determined as you view the shading surface looking at the reflective surface.

***Height, Width*.** Enter the height and width of the exterior shade in ft. DOE-2 models all exterior shades as rectangular shaped surfaces.

***Azimuth*.** Enter the azimuth of the exterior shade relative to the plan views of your model. If a surface shades the front of the model and faces the back, it has an azimuth of zero. From this reference, the azimuth is measured in a clockwise direction in degrees.

Orientation, Tilt. Enter the orientation by making a selection from the list box. The choices are vertical, horizontal and other. If you choose other, then the Tilt text box becomes active and you enter the tilt of the surface in degrees. A tilt of zero means that the reflective surface faces down. A tilt of 90 degrees is vertical and a tilt of 180 degrees means that the reflective surfaces face the sky.

Visible Reflectance. Enter the reflectance of the exterior shade. This is only relevant when you are modeling daylighting and you want to consider light bouncing off adjacent objects. A white surface has a reflectance of about 0.8 while a very dark surface has a reflectance of about 0.3.

Ground Reflectance. Enter the reflectance of the ground in front of the reflective surface. This is only relevant when daylighting is being modeled.

Transmittance Schedule, Max. Value. You can model deciduous trees or other shades with variable transmission using these features. Opaque objects have a transmission of zero and no transmission schedule need be specified. When a transmittance schedule is selected the maximum transmittance value is ignored and the transmittance is the value given by the fractional schedule. The transmittance schedule only modifies direct solar it does not modify diffuse. Diffuse and direct are modified if the maximum transmittance is specified.

Add New. Click this button to add a new exterior shades based on the current shade if any.

Delete. Click this button to remove the current shade.

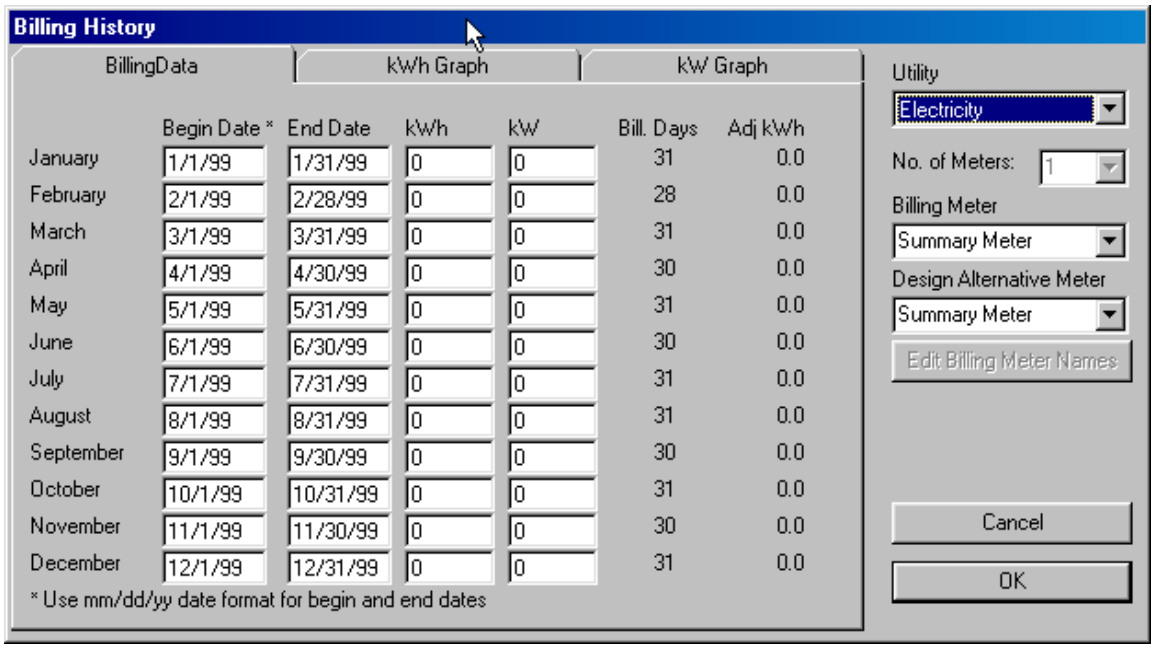
Copy Image. Click this button to copy the image of the current shade to the clipboard.

Exit. Click this button to close the form.

Enter Billing History

User can enter the utility bills with Figure 25.

Figure 25 Enter billing history

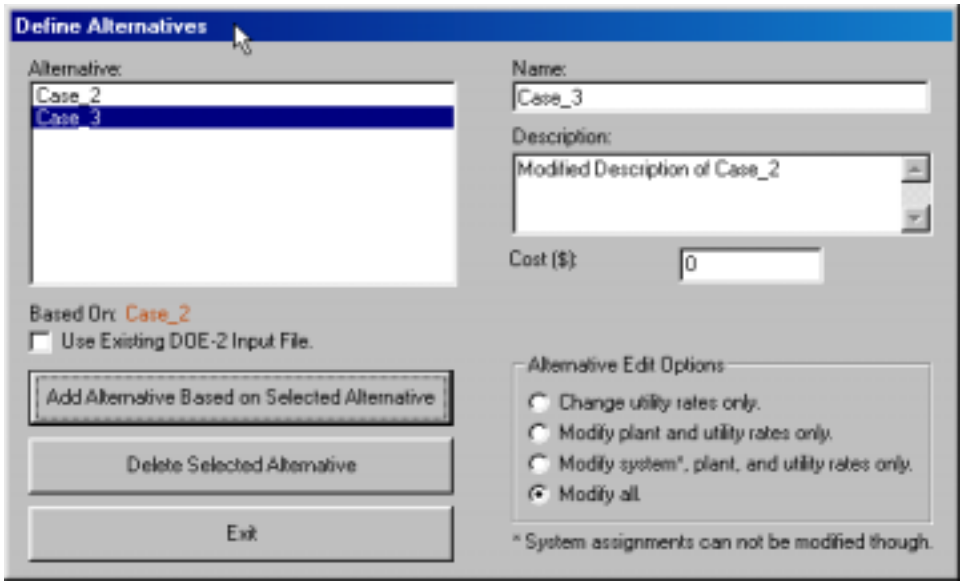


First select type of utility, either Electricity or Gas, then enter billing data including monthly beginning date, ending date, kWh, kW and Therm. The graphs show curves for existing bills and DOE-2 simulation results for comparison.

Create Alternatives

This from is activated from menu Design Alternatives | Edit Alternatives. It is used to create, modify and delete design alternatives.

Figure 26 Define Alternatives



A design alternative can be based on the base case or any design alternative previously created. All design alternatives begin as a clone of the base case or another design alternative. However once created, you can select the alternative and make modifications. For each design alternative, you specify the following information:

***Name*.** This name will appear as one of the pull-down menu options when you select Design Alternatives menu. The name will also appear in the heading of reports. Take care to use words that describe the alternative. Spaces are OK but you can't use more than 40 characters.

***Description*.** This field may be used to provide a more detailed description of the alternative. This field will accept a maximum of 120 characters. The description appears in some of the HomeEnergy reports.

***Cost*.** This field is used for the relative cost of the design alternative. HomeEnergy performs life-cycle cost calculations based on this and other information.

Alternative Edit Options. There are several ways that you can modify your design alternative. DOE-2 simulations consist of four sets of independent calculations: loads, systems, plant, and economics. HomeEnergy sorts the simulations in a way so as to minimize the time required for simulations. Plant simulations that depend on previous systems runs, etc. would follow the system simulation that they depend on. Keep in mind that when you use these options, a copy of the "Based on" design alternative is copied when you create the alternative. If you make subsequent changes to the Based on" design alternative, the new alternative will not automatically be updated.

Based On. This label shows the alternative upon which you originally based the new alternative. This may not be changed after you have created a new alternative (see below).

The following command buttons are used on the form. Their use is described below.

***Add Alternative Based on Selected Alternative*.** This command button creates a new alternative. The new alternative is a clone of the alternative that is highlighted when you click this button.

***Delete Selected Alternative*.** This command button deletes the highlighted alternative.

***Exit*.** This command button exits the Define Alternatives form.

For existing buildings, it is recommended that the base case building be completely described and calibrated with the billing history before you create the alternative designs. This will make it easier to keep track of the differences between the proposed design and the base case building. If your base case model has an error, this error will be copied to all the design alternatives, so it is best to get the base case model right before alternatives are created.

For advanced DOE-2 modelers, there is a checkbox on the define alternatives form called "Use Existing DOE-2 Input File". When checked, HomeEnergy will not recreate the DOE-2 input file for this alternative if it already exists. Instead, HomeEnergy will use an existing DOE-2 input file. This enables you to use DOE-2 Files Viewer or a text processor to edit the input file and then run the modified input file through HomeEnergy. Edits might include the addition of skylights or other features not currently supported by HomeEnergy.

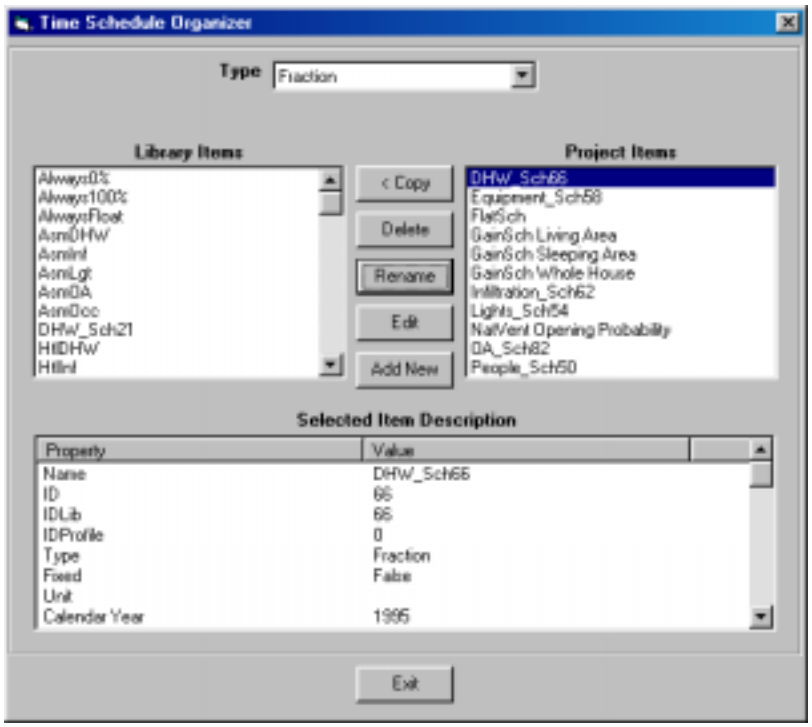
Edit Schedule Items

Organizer

No one ever wants to start from scratch when they begin a new simulation program. To save time, you always want to start with components from other projects and reuse them. These schedule items include constructions, openings, utility rates, schedules, and occupancies.

The organizer is a handy tool for doing this. It allows you to store schedule items in the library for later use. You can copy these items from the library for your project and attend to other details.

Figure 27 Organizer Form



The organizer has two list boxes located at the top of the form. The list box on the left contains schedule items from your library, while the one on the right contains schedule items in your project. To copy a schedule item from the library to your project, first select it and then click the Copy button.

You can delete a schedule item from either the library or your project by selecting it and then clicking the Delete button. You can rename a schedule item by selecting it and then clicking the Rename button. To edit a schedule item, first select it in either the library or project list and then click the Edit button.

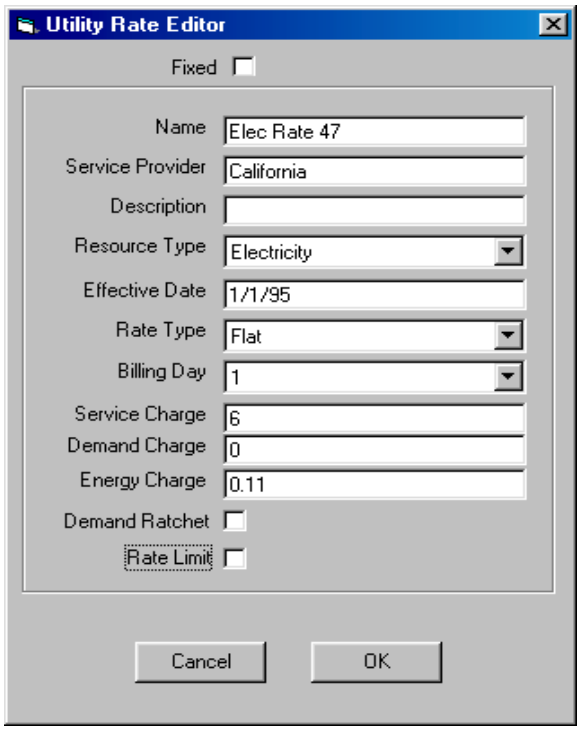
To create a new schedule item in your project, you must first select an existing schedule item and then click the Add New button. The new schedule item will be a clone of the schedule item you had previously selected. You can then edit the newly created schedule item by selecting it and clicking the Edit button.

The lower portion of the form has a table that displays information about the schedule item that is selected. You can select a schedule item only one side at a time. When you select a schedule item from the project file, nothing is selected from the library and *vice versa*.

Utility rates

For residential buildings, the electricity and gas rates are normally flat. Utility rates can be edited by clicking Edit buttons on the General Folder. Figure 28 shows the form to edit a utility rate.

Figure 28 Utility Rate Editor



Name | ***Service Provider*** | ***Description***. Name of the utility rate and service provider.

Resource Type. Choices are *Electricity*, *Diesel Oil*, *Natural Gas*, *Fuel Oil*, *Steam*, *Chilled Water*, *LPG*, *Coal*, and *Methanol*.

Effective Date. Date the rate starts to be effective.

Rate Type. Choices are *Flat* and *Time-of-Use*.

Service Charge. Monthly service charge or customer charge.

Demand Charge. Demand charge in $/kW for electricity.

Energy Charge. Energy charge in $/kWh for electricity and $/Therm for natural gas.

Demand Ratchet. Check this box if this rate has demand ratchet.

Rate Limit. Checked this box if this rate has a limit charge.

Maximum Rate. Enter the maximum charge in $/kWh for electricity and $/Therm for natural gas.

Fixed. If this box is checked, no changes can be made. Uncheck this box before making any changes.

OK. This saves data and closes the form. This button works the same way for all forms.

Cancel. This discards changes and closes the form. This button works the same way for all forms.

Schedules

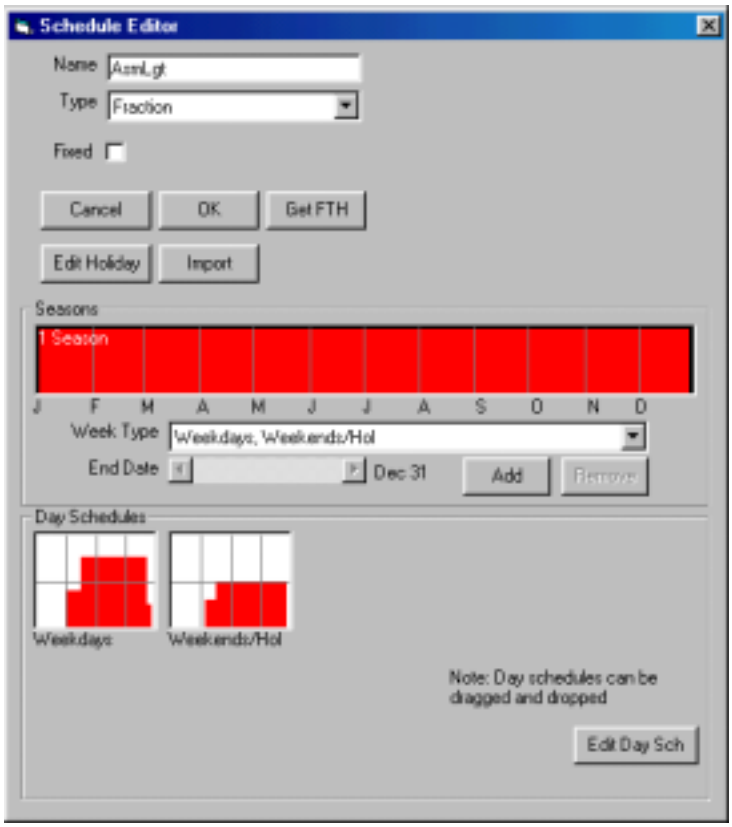
The Schedules Editor is a tool for creating and editing patterns of building operation. A schedule is an hourly time series that describes the operation of systems or equipment in buildings. Examples of things that need to be scheduled in energy simulations include lights, plug loads, miscellaneous equipment, thermostat settings, fans, occupants, and outside air ventilation. The concept of schedules is used with all simulation programs including DOE-2, EnergyPlus, and BLAST.

Creating a set of schedules in one of the first things you need to do with HomeEnergy and other simulation programs. Since many objects in your model need schedules, such as rooms, systems, etc., you will not be able to completely specify these objects if the schedules do not exist when you create the objects. In HomeEnergy, some list boxes will appear empty if you do not first create schedules. When you start a new HomeEnergy project, you can select a template and the template will set up a preliminary list of schedules for you to use. The Schedules Editor also has an organizer that can be used to copy schedules from other projects, libraries or other files.

Simulation programs use several different types of schedules. Fraction schedules are used for lights, plug loads, and occupants. For each hour of the year, the fraction schedule produces a value, generally between zero and one that represents the fraction of people that are in the space, the fraction of lights that are on, or the fraction of plug load watts that are activated. Temperature schedules are used for heating and cooling thermostat settings. On/off schedules are used for fans and other equipment. Time period schedules identify the pattern of utility charges that apply for a given hour, or to schedule the operation of equipment like gas generators or thermal storage systems.

The basic building block for simulation programs is the day schedule. The day schedule represents a 24-hour period of operation. Each value can represent a temperature, a fraction in a day schedule which is a hour patterns of use.

Figure 29 Schedule Editor



The schedules editor is used to edit an individual schedule. The editor can be launched from the Schedules Organizer when you click Edit. A schedule can have several seasons during the year that have different conditions. In each season, every day of the week is assigned a day schedule. A completed schedule will represents a time series of 8,760 hours (365 days x 24 hours/day). Day schedules are the key building blocks in constructing a schedule.

Each schedule has a name and a type. The name is a character string that describes the schedule. You may want to develop a convention for naming your schedules, since they appear in alphabetically in the list boxes. The Type field describes the type of schedule you are creating or editing.

When you are creating a schedule, you can divide the year into seasons. This may be appropriate for a school that is shut down in summer or a retail store that has longer hours during the holidays. The Seasons frame has a horizontal calendar that shows the seasons in your schedule. The number of seasons in the schedule appears in white letters over the top of the calendar. The seasons are divided with heavy black vertical lines. The current season is highlighted in red. The other seasons are shown in gray. To select a season, just click on it and it will be come highlighted. If the schedule has only one season (the most common case), the entire calendar will appear in red (highlighted).

To add a season. Click Add button to add a new season. Week Type and day schedules of the added season need to be specified.

To delete a season. Click Remove button to delete a season.

Each season has two properties associated with it. The first is the way that days are grouped for the purpose of assigning day schedules. The choices are described below:

Mon, Tue, Wed, Thu, Fri, Sat, Sun, Hol	A separate day schedule is assigned to every day of the week and an additional day schedule for holidays (8 day schedules in all are assigned)
Mon, Tue, Wed, Thu, Fri, Weekends/Hol	A separate day schedule is assigned to each weekday, but a single day schedule is assigned for Saturdays, Sundays and Holidays (6 day schedules are assigned)
Weekdays, Sat, Sun, Hol	One day schedule is assigned to all week days, but separate day schedules are assigned to Saturdays, Sundays and Holidays (4 day schedules are assigned)
Weekdays, Weekends/Hol	One day schedule is assigned for weekdays and a separate day schedule is assigned for weekends and holidays (3 day schedules are assigned)
All	Every day has the same day schedule (only one day schedule is assigned)

Each season has an end date (its beginning date is the day following the end date of the previous season). There are a couple of ways to change the end date for a selected season: (1) you can hold down the right mouse button and drag the horizontal bar or (2) you can use the horizontal scroll bar labeled “End Date”. Depending on how days are grouped (see above), up to eight day schedules are assigned to each season. the type of day schedules that are assigned depend on the schedule type, e.g. if the schedule is a fraction schedule, then only fraction type day schedules can be assigned.

The day schedules associated with the seasons are represented as graphic icons located beneath the seasons frame. Double click on one of the day schedules to edit it. Alternatively, you can right mouse click and choose Edit. Either or these operations will launch the Day Schedule Editor Figure 30.

Get FTH. For fraction and on/off schedules, this gets the full equivalent hours of the schedule.

Edit Holiday. Click this to edit holidays. The holiday applies to all schedules in a project.

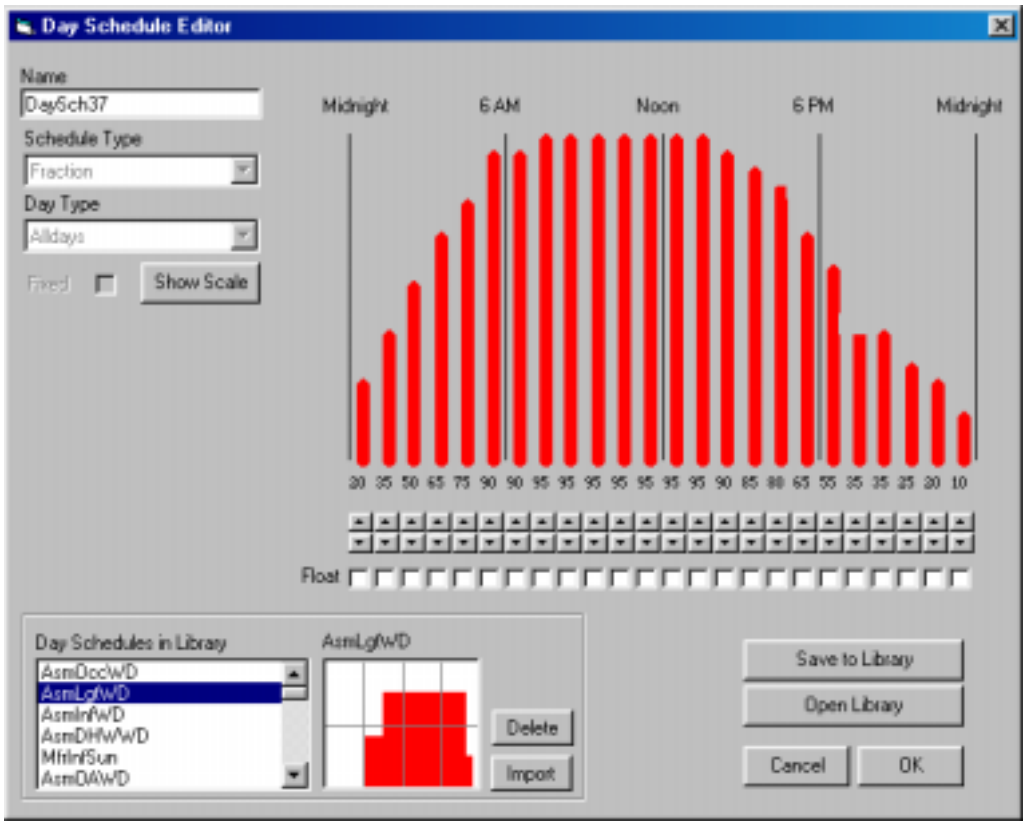
Import. Click this to launch a form for importing a time series to create a schedule.

OK. This saves data and closes the form.

Cancel. This closes the from without saving any changes.

The Day Schedule Editor is launched by double clicking on one of the day schedule icons located on the Schedules Editor. The Day Schedule Editor looks a little differently depending on the type of schedule that is being edited. The following form is for a fraction type schedule.

Figure 30 Day Schedule Editor



The Day Schedule Editor is used to build day schedules, which are 24-hour patterns of use. There are four types of day schedules: Fraction, On/Off, Temperature and Time Period, but you can generally not change the type from the Day Schedule Editor. The schedule type is generally set by the parent Schedule Editor.

You can edit the selected day schedule by using the up and down arrows beneath each bar. The amount of change associated with each click will depend on the type of schedule you have selected. On/Off schedules jump between zero and 100%, while fraction schedules jump in 5% increments (but this default can be changed by clicking Show Scale button). Temperature schedules jump in 1 degree increments.

On/off and fraction type day schedules can have a special condition for a given hour called Float. When Float is checked, the value for that hour is calculated by DOE-2 based on other information. In the DOE-2 input file, this usually means that a -999 is assigned to that hour. When float is checked, the numeric value for that hour is not relevant.

You can also edit a day schedule by using the mouse. When you position the mouse over the red bars, the cursor changes to cross hairs and a small number is displayed representing the position of the mouse. A click with the left mouse button changes the bar to the value on the cursor. You can also hold down the left mouse button and drag the cursor across the bars and the value will be changed across all the hours.

Show Scale. This shows a frame where user can set the maximum, minimum and step before editing the day schedule. Click Set Scale to active changes.

Open Library. This opens the library and listed all day schedules of the current type in the library for user to view or import.

Save to Library. This save the edited day schedule to the library. This button is visible after the library is opened.

Import. This imports the day schedule from the library to the edited day schedule.

Delete. This deletes the selected day schedule form the library.

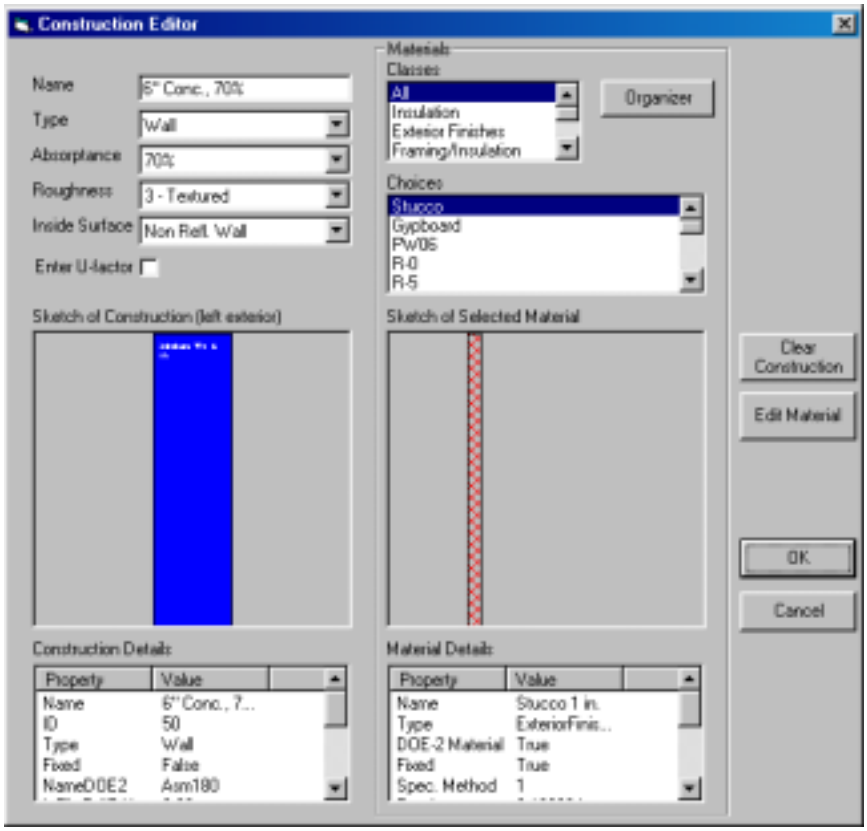
OK. This saves day schedule and closes the form.

Cancel. This cancels all changes made and the day schedule is not changed.

Constructions

User can right mouse click the material layers of the construction to delete a layer, edit a layer by launching the Material Editor, and add a layer by drag-and-drop a material layer from the Sketch of Selected Material box.

Figure 31 Construction Editor



Name. Name of the construction should be unique and less than 16 characters.

Type. Choices are Wall, Roof, Floor, Slab, Below-Grade Wall, Partition, Ceiling, and Door.

Absorptance. The absorptance is the fraction (or percent) of solar radiation that is absorbed by the exterior surface of the construction assembly when sunlight strikes the surface. Dark colors have a high absorptance, 70% or higher. Light colors have an absorptance between about 30% and 50%.

Roughness. The roughness of the finished outside surface of a wall. Used only for exterior walls (or roofs). DOE-2 uses this value and the hourly wind speed to determine the contribution of the exterior air film to the overall U-Value of the wall. Generally, the effective U-Value of the door is higher when the wind speed is lower, and when the surface is more rough (i.e., the effective U-Value of the door is higher for stucco walls than it is for glass or paint on pine). There are six choices representing integers between 1 and 6. The following are some examples of surfaces that fall in the six categories.

1 *Very Rough*. e.g. stucco walls, wood shingle roofs, or built-up roof with stones

2 *Rough*. e.g. brick or plaster.

3 *Textured*. e.g. poured concrete walls, or asphalt shingle roofs.

4 *Flat*. e.g. painted wood siding.

5 *Smooth*. e.g. unpolished marble, smooth plaster, or metal.

6 *Polished*. e.g. glass, polished marble, or chrome finished metal.

Inside Surface. For specifying the inside surface air film resistance. The inside surface condition affects the overall U-factor of the construction assembly. Make a selection from this list box that is appropriate for the assembly you are defining.

Enter U-factor. Check this box to enter a construction in U-factor method.

Clear Construction. This command clears the Sketch of Construction

Construction Details. Properties of the construction are listed here.

Sketch of Construction. For walls, the most left layer is the exterior layer. For Roofs and Ceilings, the top layer is the exterior layer. For Floors, the bottom layer is the exterior layer.

Material Classes. Choices are Insulation, ExteriorFinishes, FramingInsulation, InteriorFinishes, Concrete, Masonry, and AirLayers.

Choices. Materials of the selected class are listed. Select a material to display it in the Sketch box.

Edit Material. Click this button or double click the material to launch the Material Editor.

Organizer. This command launches the Materials Organizer.

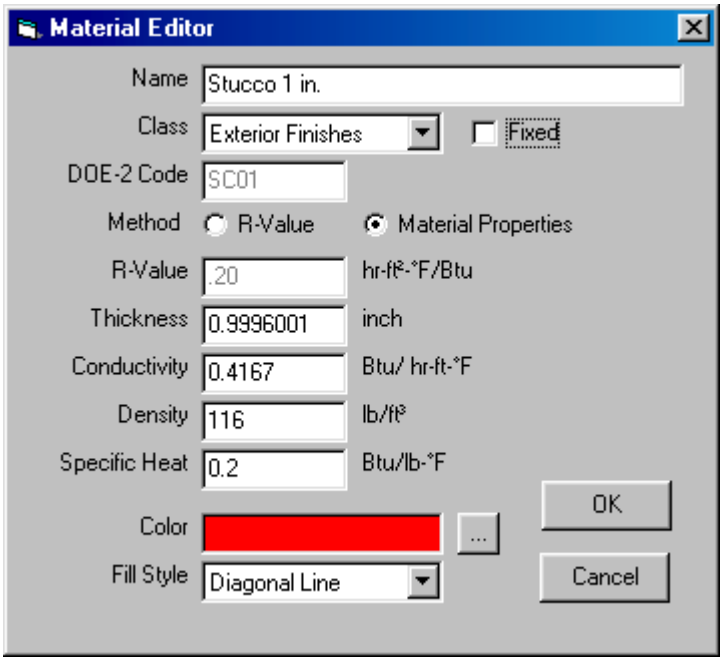
Material Details. Properties of the material are listed here.

OK. This command updates the construction and closes the form.

Cancel. This command closes the form and discards all changes to the construction.

Figure 32 Material Editor form is used to edit materials. Materials are the building blocks of construction assemblies. User uses this form to input a material in two methods, R-Value and Material Properties.

Figure 32 Material Editor



Name. Name of the material should be unique and less than 16 characters.

Class. Choices are Insulation, Exterior Finishes, Framing/Insulation, Interior Finishes, Concrete, Masonry, and Air Layers.

DOE-2 Code. DOE-2 Code is shown if the material is a standard DOE-2 material.

Method. Select a method to input properties of material.

Thickness. Thickness of the material layer. If a material is defined in R-value method, the thickness is only used in drawing the material layer, it is not used in calculating the R-value of the material.

R-Value. R-Value of the layer.

Conductivity. Conductivity of the material.

Density. Density of the material.

Specific Heat. Specific heat of the material.

Color. Color of the material when shown in the construction sketch.

Fill Style. Fill Style of the material when shown in the construction sketch.

Fixed. This has to be unchecked before changes can be made.

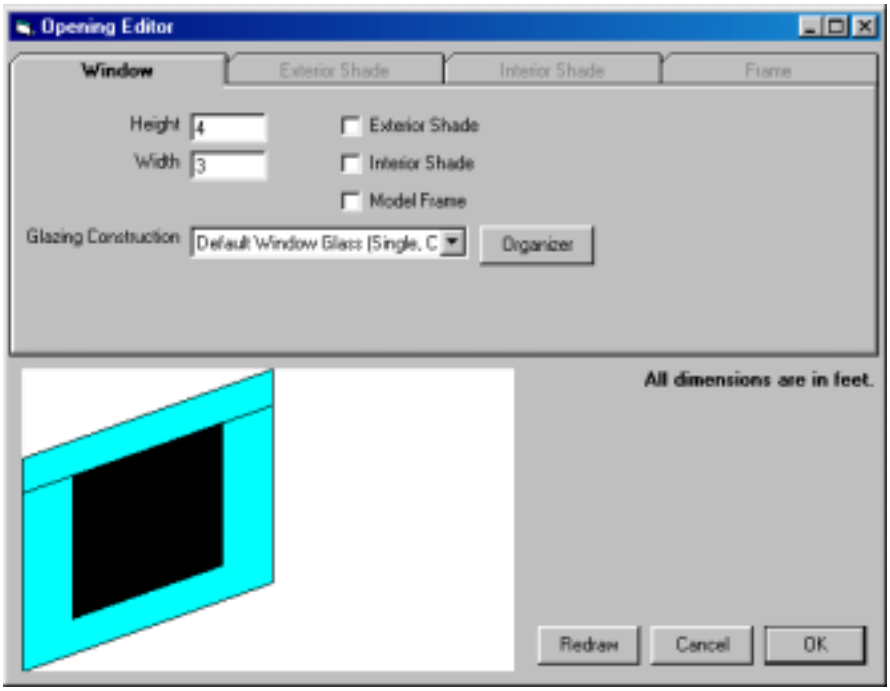
Cancel. This command cancels changes made and closes the form.

OK. This saves changes made and closes the form.

Openings

Openings include windows, skylights and doors. Figure 33 shows interface to edit windows.

Figure 33 Opening Editor



Height. Enter height of the window including the frame width.

Width. Enter width of the window including the frame width.

Exterior Shade. Check the box if the opening has exterior shading. Enter more data at the Exterior Shade tab.

Interior Shade. Check the box if the opening has interior shading. Enter more data at the Interior Shade tab.

Model Frame. Check the box if the opening has detailed frame data. Enter more data at the Frame tab.

Glazing Construction. Select one the glazing from the drop down list.

Organizer. Click this button to import more glazing constructions.

Redraw. Click this button to redraw the image of the opening.

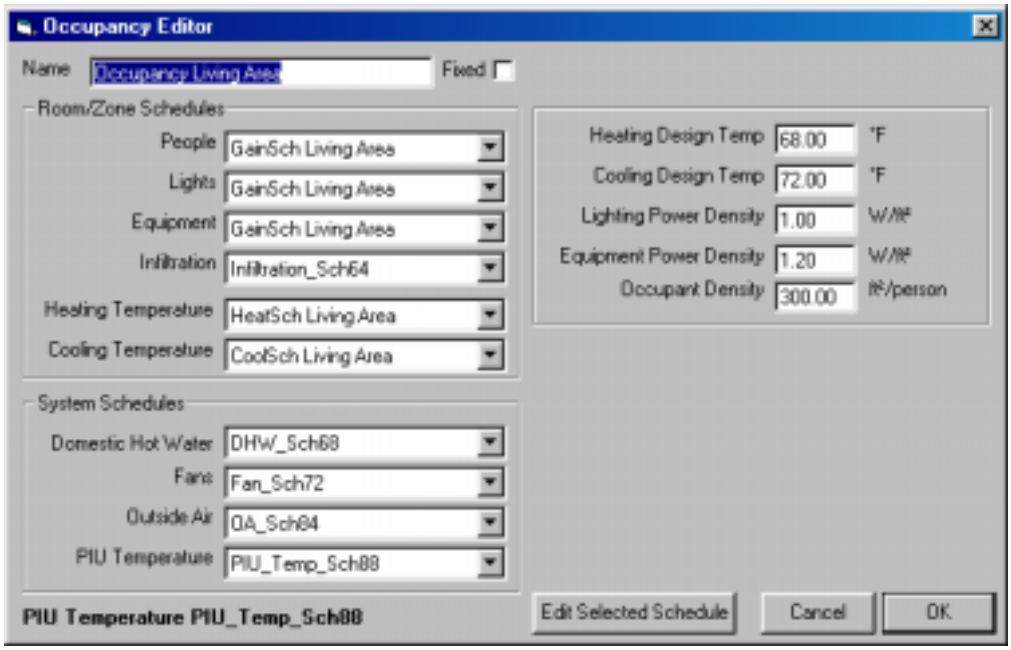
Cancel. Click this button to discard changes and closes the form.

OK. Click this button to save changes made and closes the form.

Occupancies

The Occupancy Editor is used to edit an occupancy either in the library or in a project file. An occupancy is a collection of schedules and other data that characterize an occupancy such as a school, office, or retail store.

Figure 34 Occupancy Editor



Name. Enter a name to describe the occupancy. The name will appear in list boxes for you to choose, so it should be descriptive and distinguishable from other occupancies.

Room/Zone and System Schedules. The drop-down list boxes for people, lights, etc. only contain the appropriate schedule types. The most common schedule type is the Fraction schedule which is used for people, lights, equipment power, infiltration, domestic hot water, and outside air. On/Off schedules are used for fans, and Temperature schedules are used for heating temperatures, cooling temperatures and PIU temperatures.

Each occupancy also has a default heating and cooling design temperature, lighting power density, equipment power density, and occupant density. These values are optionally assigned to rooms when you change the occupancy type.

Edit Selected Schedule. Select a schedule and click this button to edit it.

OK. This saves changes and closes the form.

Cancel. This discards changes and closes the form.

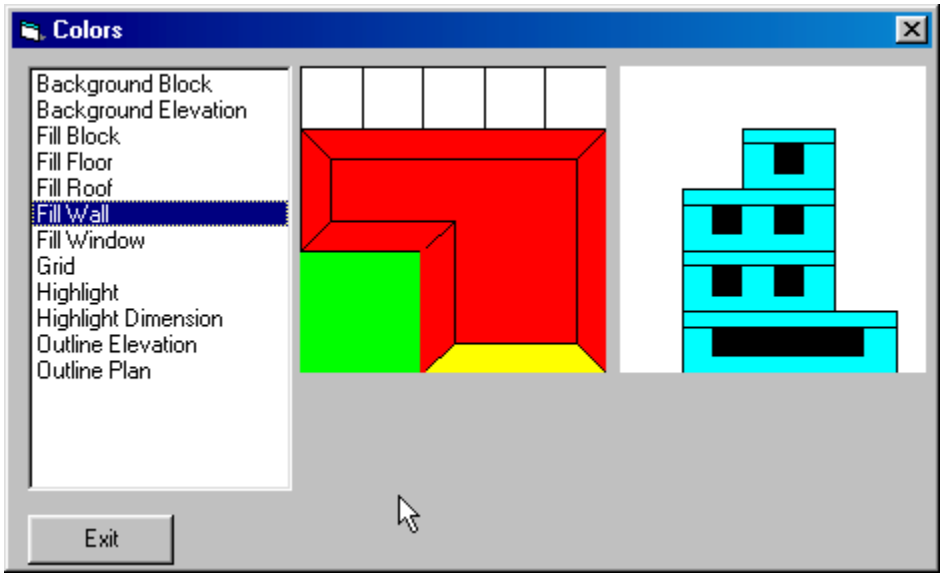
Set Options

User can select menu Tools | Options to change settings of color, grid and DOE-2 path.

Colors

The colors form is used to set the colors on the plan and 3D views.

Figure 35 Color Settings

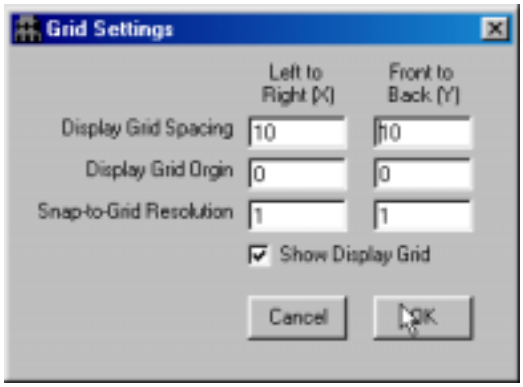


A list box on the left side of the form displays the elements for which a color can be assigned. Double click on an element and a color dialog box will appear where you can choose a color. As you select colors, the sample plan and elevation views on the right side of the form display the colors you have selected. When you exit the form, the plan and 3D views settings are saved until you change them again.

Grid

The grid setup form is used to determine the grid to display on the plan views on your model.

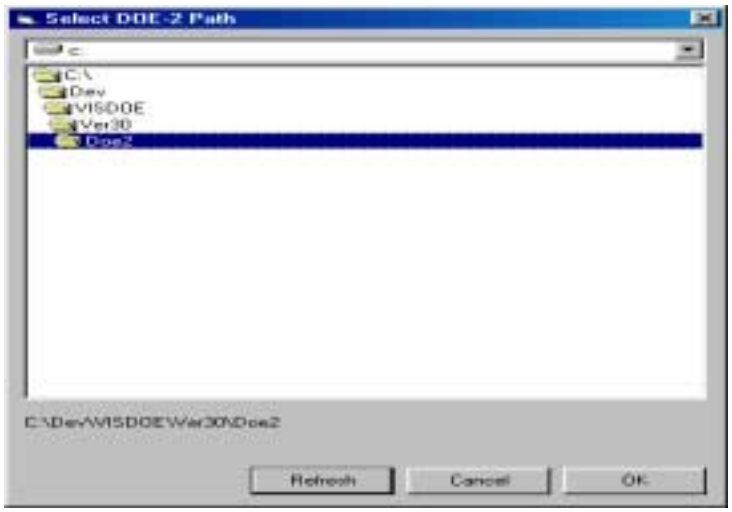
Figure 36 Grid Settings



This form is activated from the main form when you select Tools | Options | Grid Settings. You indicate if you want a grid displayed at all by clicking the checkbox. You enter the grid spacing in both directions: front to back and left to right. Finally, you can indicate the X and Y coordinates for the origin of the grid. The grid is handy when you are reviewing your block plans

Path to DOE-2 Engine

Figure 37 Path to DOE-2 Engine



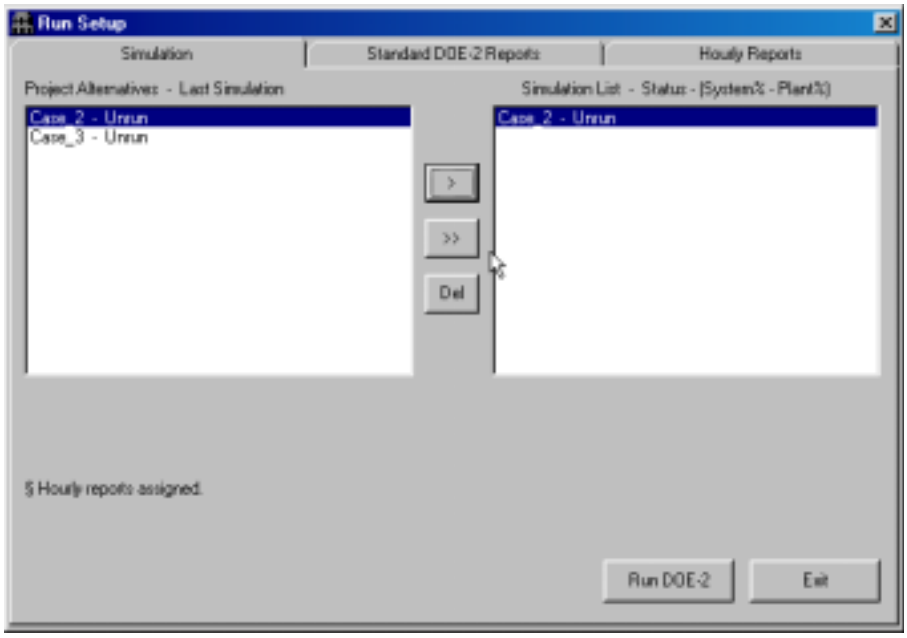
This is form is launched by selecting menu Tools | Options | Path to DOE-2 Engine in the main form. Double click the directory containing files for DOE-2 simulation engine. Click to OK to close the form.

When HomeEnergy is installed, the default DOE-2 path is C:\Program Files\GDT\DOE-2.

Setup and Run

After creating the house model, user needs to specify those alternatives to run.

Figure 38 Setup and Run



The list box on the left has all the design alternatives that we have created. At this point only one item will appear in the list. In the future, however, you can create other design alternatives to evaluate the energy savings that might result from making changes to your house The list box on the right side is a list of design alternatives for which you want to do calculations. The one design alternative should already appear in this list box. The *Run Setup* form has three tabs: *Simulation*, *Standard DOE-2 Reports*, and *Hourly Reports*.

To begin the simulation, click the *Run DOE-2* button. A DOS box will appear until the simulation is complete.

The Run Setup form is activated from the HomeEnergy main form when you select Simulation | Run Setup from the pull-down menus choices. The form is organized on three folders. The first folder controls the simulations that you want to make. The second folder is used to select the DOE-2 reports that you want to produce when the simulations are made. The third folder is used to assign hourly report variable sets to zones, systems and other project components.

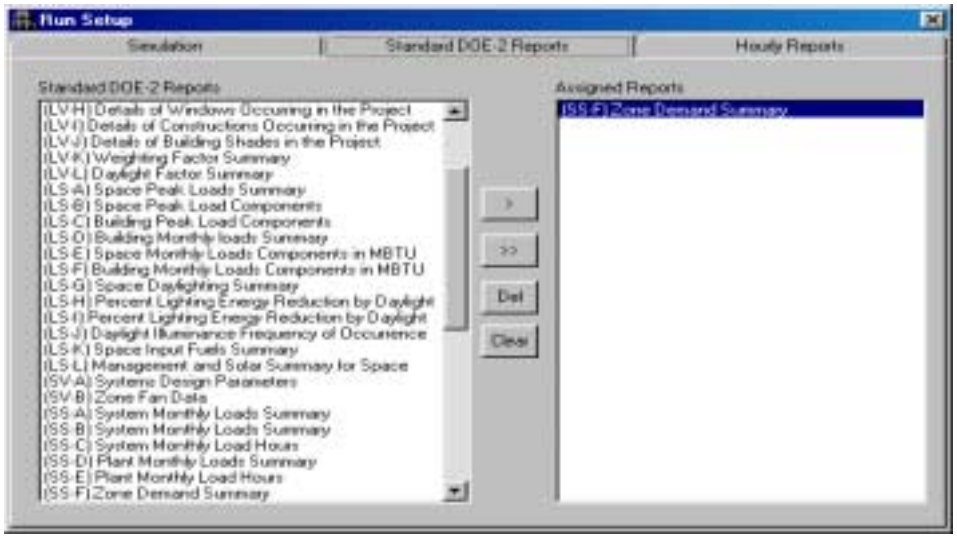
Simulation Folder. The simulation folder is used to select the alternatives that you want to include in your simulations. The form consists of two list boxes. The list box on the left contains the base case and each of the design alternatives that have been created. The list box on the right contains the cases that you want to include in the runs you are about to make. To add the base case or one of the design alternatives to the simulation list, (1) select the case from the list box on the left and (2) press the ">" command button. Alternatively, you can double click on the design alternative an it will be added to the simulation list. To add all design alternatives to the simulation list, press the ">>" command button. To remove a design alternative from the simulation list, select the design alternative and press the "Del" command button.

If a simulation has already been made, the Project Alternatives list includes the date of the last simulation. After each successful run HomeEnergy extracts information from the DOE-2 output files. This information can be viewed by selecting Simulation | View Reports. You can also graph the results by choosing Simulation | View Graphs.

HomeEnergy allows you to assign hourly reports to any or all of the design alternatives. Even through you have assigned hourly reports to design alternatives, you can choose not to generate the hourly reports when you make your simulations. You may want to do this to save disk space, since the hourly reports can take considerable space, especially if you generate them for an entire year.

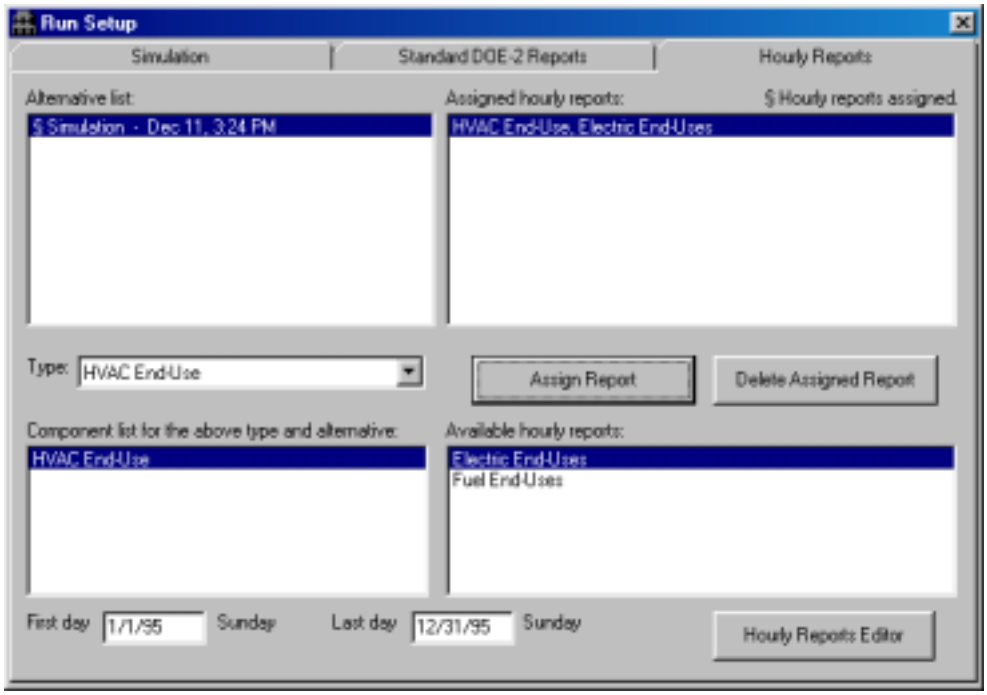
***Standard DOE-2 Reports*.** The Standard DOE-2 Reports Folder is used to select the DOE-2 reports that you want produced for your simulations. The standard DOE-2 Reports are listed on the left side of the form. Double click on one to add it to the project reports list on the right. Alternatively, you can select the report you want to add to the list and click the ">" command button. The ">>" command button adds all reports to the project reports list. The "Del" command button removes the highlighted project report from the list.

Figure 39 DOE-2 Standard Reports



Hourly Reports. Use the hourly reports tab to define the hourly reports that you want to generate. These reports are produced when the simulation is made. Once the hourly reports are created, you can graph them in View Graphs. The hourly report files have the same file name as the project with the extension *.h0 for the base case, *.h1 for the first alternative, etc. These files can be opened in a text processor so that data can be pasted into spreadsheets or other applications. The files are marked as read-only, however, so their format or content is not changed.

Figure 40 DOE-2 Hourly Reports



The hourly report folder is organized with a series of list boxes and other miscellaneous controls. A list of the design alternatives is displayed at the top left corner of the form. Alternatives with a "§" character in front of them have hourly reports assigned to them. Just to the right is a list of the hourly reports that are assigned to the selected alternative.

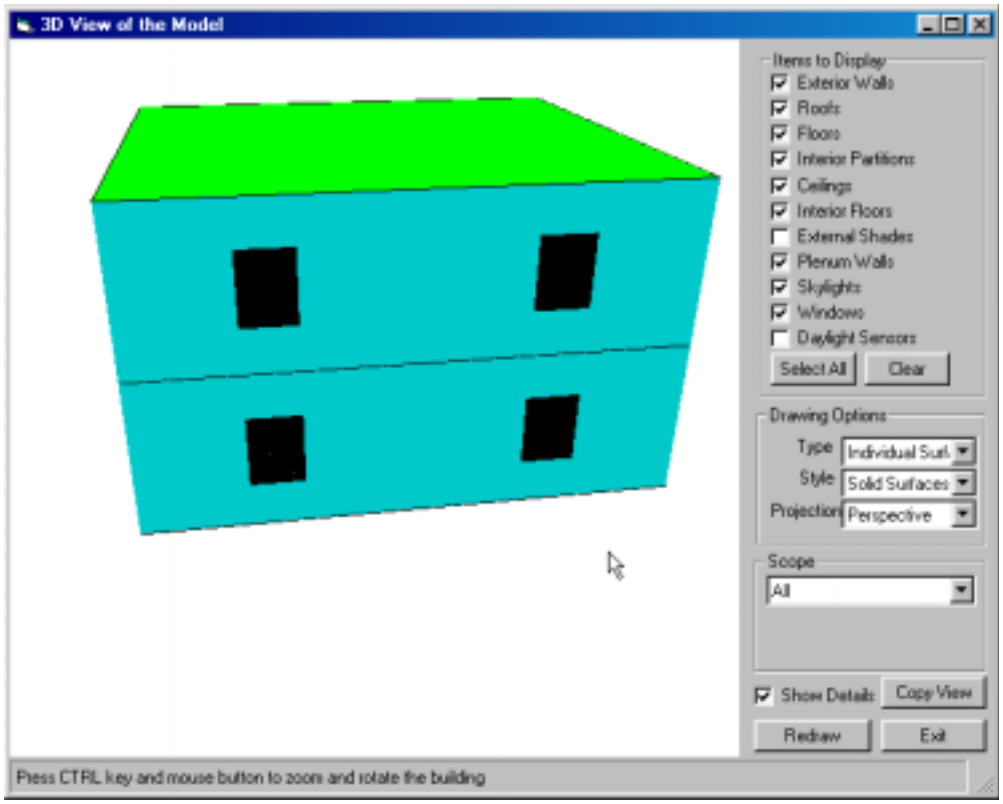
To assign an hourly report to a design alternative, carry out the following steps.

	Step	Program Response / Notes
1.	Select the design alternative from the list box in the upper left corner of the folder.	Any hourly reports already assigned to the alternative will show in the Assigned Hourly Reports list box. The hourly report type list box is refilled with hourly report types available for this alternative.
2.	Choose an hourly report type from the drop down list box.	The Components and Hourly Report list boxes will be refreshed for the selected hourly report type.
3.	Choose a Component from the list box.	This list will often have just one choice, however, the list will be filled with all the building components that can have the hourly report type selected assigned to them.
4.	Select a Hourly Report from the list box.	This list box contains a list of the hourly report defined for the selected variable type. If none exist, you will be advised. You can add variable sets by opening the Hourly Reports Editor.
5.	Click the Assign Report command button.	The hourly report variable set is assigned to the selected component and added to the Assigned Hourly Reports list box.
6.	Specify the first and last days the reports will be printed.	Try to avoid specifying the entire year because a very large file will be produced. The reports can only be specified for the year 1995 at this time.
7.	Repeat steps 1 through 6 until you have assigned hourly reports as desired.	

3D Viewer

This form shows a three dimensional view of the building model. User can change items to show and copy the image for reporting. Press the left mouse button and move the mouse while pressing the Ctrl key will zoom the view. Press the right mouse button and move the mouse while pressing the Ctrl key will rotate the view.

Figure 41 3D Viewer



Items to Display. Select or deselect items to show in the view. Click Select All button to select all items, click Clear button to deselect all items. The view will be refreshed automatically.

Drawing Options. Type can be Floor Plans or Individual Surfaces, Style can be Solid Surfaces, Wire Frame, Points, or Projection can be Perspective or Orthogonal. User needs to click the Redraw button to refresh the view.

Scope. Scope can be All, Selected Block or Selected Room. This will show portion of the 3D view of the model.

Show Details. If this box is not checked, user can't change viewing options.

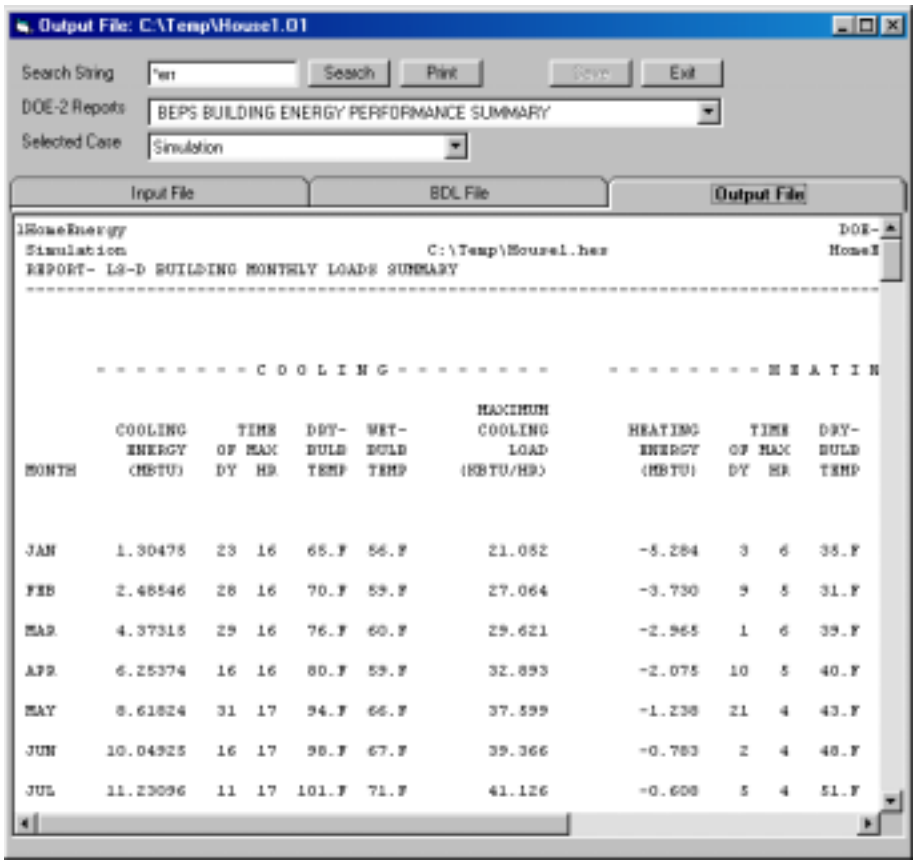
Copy View. Click this button to copy the image of the 3D view to the clipboard.

Redraw. Click this button to redraw the view if drawing Type and Style are changed.

View DOE-2 Files

This form is useful for user to identify errors in the model and browse the input and output of the project.

Figure 42 DOE-2 Files Viewer



User can browse contents of the project files including input file (*.i??), BDL file (*.b??) and output file (*.o??), search error or warning messages in BDL file, and look at the DOE-2 reports in the output file by selecting a report from the DOE-2 Reports combo box. Contents of the files can also be printed.

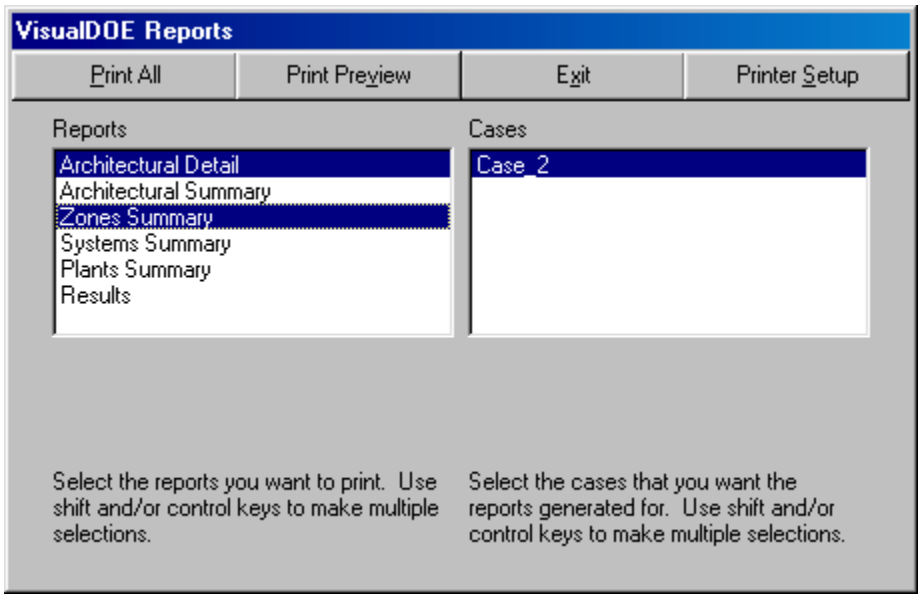
User can also modify the input file and run DOE-2 simulations if the alternative has checked Use Existing DOE-2 Input Files at Edit Alternatives form.

User can view DOE2 files for other cases by selecting other case without leaving the form.

View Results

After making successful DOE-2 simulations, user can view reports produced by the program.

Figure 43 View Reports Setup



In addition to the reports produced by DOE-2, the HomeEnergy interface produces some summary reports as described below. You can generate these reports for viewing on the screen or for printing while you are developing your model. The results report will, of course, be incomplete until you have performed a simulation. To generate HomeEnergy reports:

1 Select Simulation | View Reports from the pull-down menu.

2 This will cause a form to appear with two list boxes. One list box shows the reports that are available and the other shows the base case and design alternatives that you have created.

3 Select the report(s) and alternative(s) for which you wish to generate reports. You can make multiple selections from both lists.

The following is a brief description of each of the HomeEnergy reports. You can also simply view the reports on the screen to evaluate their content.

1 *Architectural Summary*. This report is a summary of the surface areas and window areas in the building broken down by construction type.

2 *Architectural Detail*. This report summarizes the information that you entered about the construction materials size and shape of the building along with details about the windows on each facade.

3 *Zones Summary.* This report summarizes information about the zones in the building, including internal loads, supply air volumes and outside air volumes.

4 *Systems Summary.* This report summarizes information about each of the systems.

5 *Plant Summary.* This report summarizes information about the central plant components.

6 *Results. Once the simulations are complete, HomeEnergy will extract a summary of end-use energy, monthly electricity use, monthly gas use, and peak demand by month, annual gas cost, annual electricity cost and the source energy use in kBtu/y-ft². These data will be displayed and then placed in the project database for either the base case or the proposed design, depending on the type of simulation you performed.*

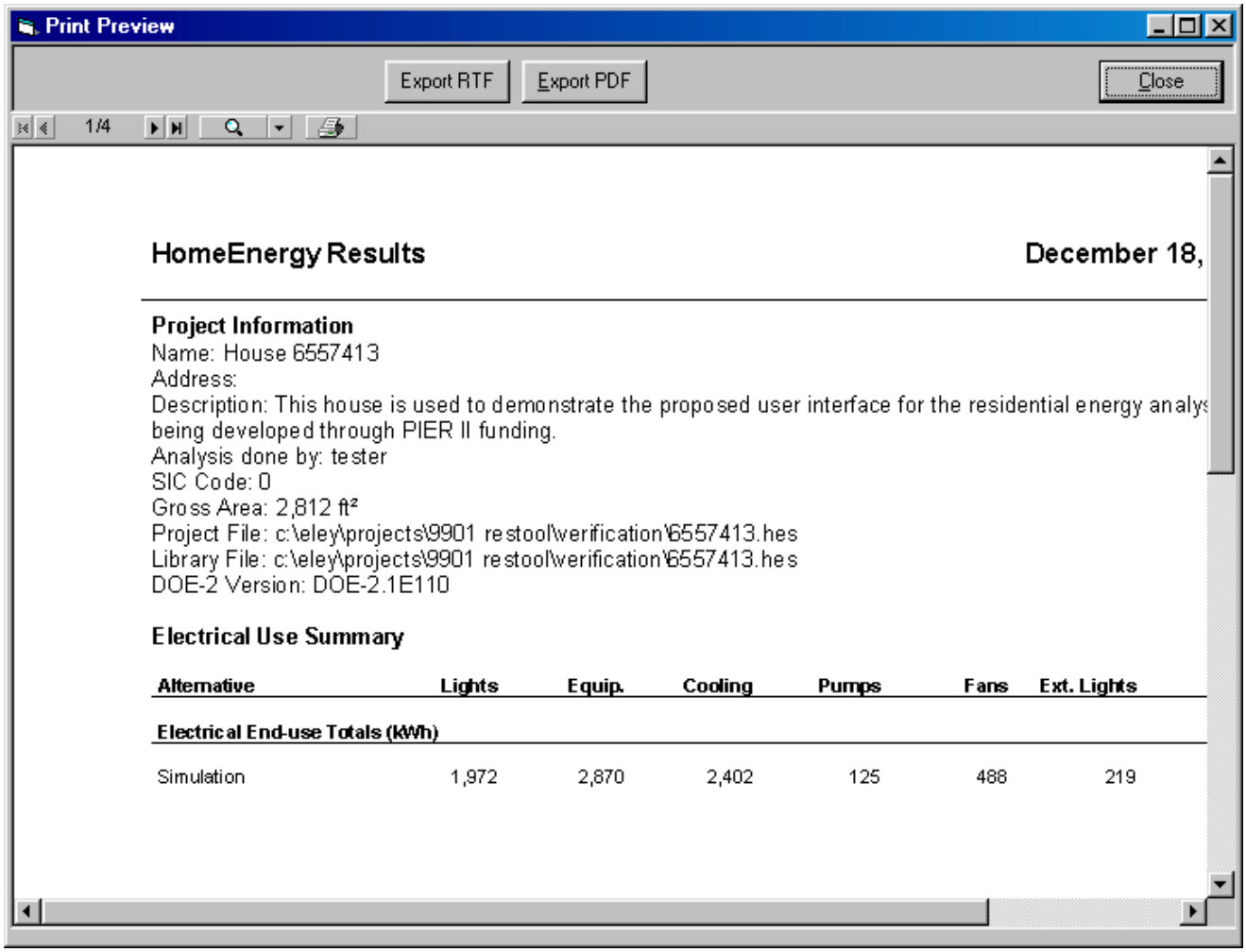
Print All. Click this button to print all reports selected.

Print Preview. Click this button to preview the reports (Figure 44) where you can zoom in/out.

Printer Setup. Click this button to launch a form to change settings of the printer you are going to use.

Exit. Click this button to close the form.

Figure 44 HomeEnergy Reports



With this form, user can preview the reports selected, zoom them out/in, and print them.

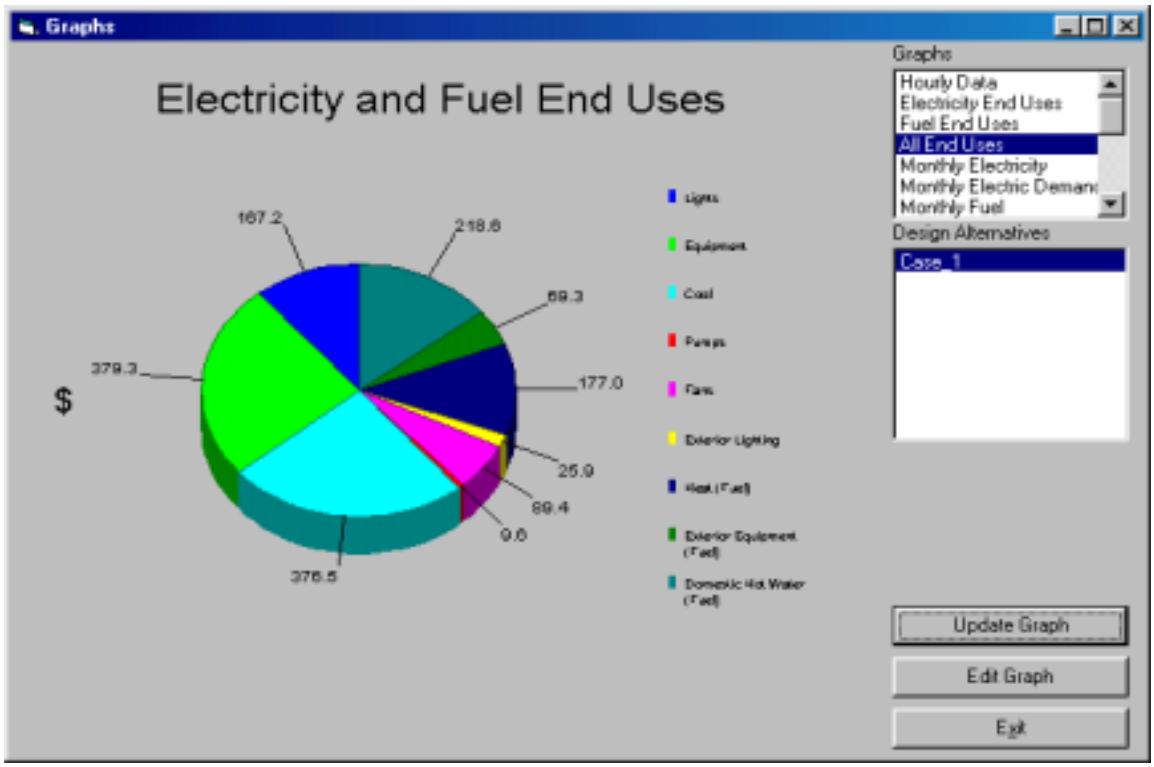
Export RTF. Click this button to export the report to an RTF file.

Export PDF. Click this button to export the report to a PDF file.

View Graphs

After making successful DOE-2 simulations, user can also view graphs produced by the program.

Figure 45 HomeEnergy Graphs



This form is activated by choosing Simulation | View Graphs. This form is used to graph simulation results, weather data or hourly reports. Graphs fall into three categories. The available graph names for each are shown in the columns below.

Category	Graph Name	Notes
Hourly Graphs	Depend on hourly reports that have been generated	To make hourly graphs, you must first generate an hourly report file for one or more of the design alternatives.
Summary Graphs	Electricity End Uses Fuel End Uses All End Uses Monthly Electricity Use Monthly Electricity Demand Monthly Fuel Use Month Elect. and Fuel Use Energy Costs	You must make a successful simulation for one or more of the design alternatives before you can display the summary graphs.
Weather Data Graphs	Average Temperatures Degree Days Wind Speed Skycover Relative Humidity Daily Solar Hourly Solar Temperature Surface Plot	Weather data can be plotted even before simulations are completed. You must, however, create a statistics file for the climate you have selected.

To print the graph or copy it to the Windows clipboard, move the mouse over the graph and click with the right mouse button. A form will appear above the graph with several tabs or folders. Go to the Systems folder on this form and take the appropriate action.

Use Library

The project files are independent upon the library. It is good practice to backup library from time to time in case the library corrupts. A backup library can be imported as the current library.

Backup library

Select menu File | Library | Backup to backup the current library vdeo3.lib to a file with extension of lbk.

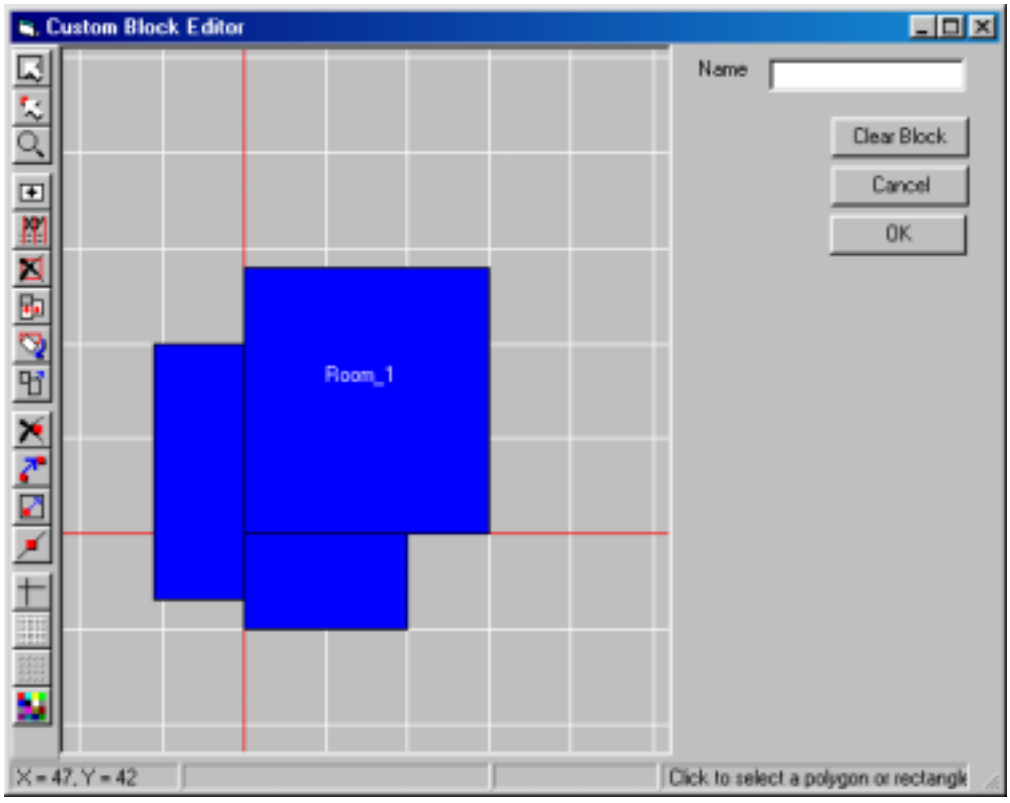
Restore library

Select menu File | Library | Open to restore a library backup (.lbk) or use another library (.lib).

Custom Block Editor

Besides auto building a house, user can customize the floor plans of the house. User first auto builds a dummy Tract or Ranch type house, change House Style to Customize, and double click each plan view to customize it with the Custom Block Editor (Figure 46).

Figure 46 Custom Block Editor



The Custom Block Editor is a key component of the program that allows you to create blocks of special shapes or blocks or with unusual zoning configurations. All blocks, including custom blocks, are a collection of rooms that have certain properties in common, including the floor-to-floor height, number of floors (floor multiplier in DOE-2 terms), the vertical position (height above the ground), roof construction, ceiling construction and floor construction. You can think of a block as a typical floor in the building, although this is somewhat of a simplification.

You create a custom block by dropping the custom block icon (hexagon) on the plan views. When a standard block has been converted to a custom block, you can merge rooms, delete rooms, relocate vertices, and perform other custom block functions. Once converted, however, you loose the convenience of being able to change the overall dimensions of the block and have all the rooms change shape accordingly.

You create a custom block by adding rooms one at a time. Rooms can be created by drawing them as a rectangle or a polygon, by entering the X Y coordinates, or by importing data from a CADD file. The latter approach is useful if you already have a CADD drawing of the building you are modeling and are experienced in using CADD programs.

Custom Block Editor, Toolbar Summary

Select Room
Select Vertex
Zoom
Add Room
Edit Room
Delete Room
Combine Rooms
Rotate Block
Move Block
Delete Vertex
Move Vertex
Move Daylight Reference Point(s)
Insert Vertex
Snap Settings
Color Settings
Toggle Grid
Grid Settings

Custom Block Editor, Creating a New Block

The Custom Block Editor has a large drawing area on the left side of the form that is used to draw the outline of each of the rooms that make up a block. The process of creating a block is as follows:

	Step	Program Response
1.	Choose the .	A form will be launched where you can set the grid settings. Enter the grid spacing and snap-to-grid resolution that you want to work with.
2.	Choose and then to turn on Snap-to-Grid.	As you move the mouse over the drawing space the coordinates displayed in the status bar will “jump” to the nearest snap-to-grid resolution.
3.	Choose and then and zoom to the portion of the drawing where you want to add a room.	As you drag the mouse, an outline will appear showing the rectangular area you are zooming to.
4.	Choose and then to add a room by creating a two-point rectangle	As you drag the mouse over the drawing space an outline will appear showing you the size of the rectangular shaped room you are creating.
5.	Choose and then to add a room by creating a polygon.	Chick once with the mouse to set a vertex of the polygon. As you move the mouse to another position, a “rubber band” will appear

showing the line segment you are about to create. Click again to set another vertex. Click with the right mouse button to close the polygon.

6. Choose  to position the daylight reference points in each of the rooms in your block.

Hint: The current mouse position is displayed in the status bar. This is helpful in accurately creating rooms.

Custom Block Editor, Editing a Custom Block

After a custom block has been created, it can be subsequently edited. To edit a zone, choose Options|Grouped Zone Editing and turn this feature off (no check mark). Next you select the zone you want to edit. You can select a zone by clicking on it in the drawing area or by selecting it from the zones list. You can tell which zone is selected because the vertices that define it are highlighted by small squares. The daylighting control sensor will also be shown. After a zone has been selected, there are several editing functions that you can perform:

- *You can move the custom block in its entirety.* To do this, choose the  (Move Block) tool. Click anywhere on the custom block and drag it to the new location. If Snap-to-Grid is on, the behavior of this tool is affected by the Grid Settings and by the status of Snap-to-Grid.
- *You can rotate a custom block.* Choose the  (Rotate Block) tool. The first step is the mark the pivot point around which you want to rotate the block. Click once with the mouse to do this. The second step is to hold down the left mouse key and drag until the block is rotated to where you want it to be. When you release the mouse, the block will be rotated to the new position. If Snap-to-Grid is on, the block is rotated to the nearest Snap Angle as you drag the mouse.
- *You can move a vertex.* Choose the  (Move Vertex) tool. All the vertices will be displayed. Click on the one you want to move, hold down the mouse and drag it to the new position. When you release the mouse the custom block will be reconfigured. When you drag a vertex, you can't create a self-intersecting polygon or violate any of the other custom block rules. HomeEnergy will check for these and other conditions and display a message if the move is not successful.
- *You can delete a vertex.* Choose the  (Select Vertex) tool and select the vertex that you want to delete. Then choose the  (Delete Vertex) tool. HomeEnergy will then attempt to delete the vertex. If the operation is not successful, a message will be displayed. A vertex can't be deleted if it adjoins two or more rooms.
- *Delete a room*. Choose the  (Select Room) tool and select the room that you want to delete. Then chose the  (Delete Room) tool. HomeEnergy will then attempt to delete the room. If deleting the room violates the custom block rules, then the operation fails and a message is displayed for the user. The Delete Room tool is enabled when one and only room is selected.
- *Combine rooms*. Choose the  (Select Room) tool and select the two rooms that you want to combine. Then chose the  (Combine Rooms) tool. The combine rooms tool is visible only when two rooms are selected.
- *Relocate the daylighting reference point(s).* Choose the  (Move Daylight Reference Point(s)) tool. With this tool, select a room, which will be come highlighted. The daylight reference points within the room will also be displayed. Click on one of the daylight reference points and drag it to a new location. Each room has two daylight reference points, which are shown in different colors. The status bar tells you which one you are moving.
- *Insert a vertex.* Choose the  (Insert Vertex) tool. Click on the line segment where you want to insert the vertex. Once the vertex has been added, you can relocate it using the  (Move Vertex) tool.

- *Edit room coordinates.* Choose the (Select Room) tool and select the room that you want to edit. Then chose the (Edit Room) tool. This will cause a spreadsheet like control to appear with the coordinates of the selected room. Modify the coordinates within the spreadsheet control. The Edit Room tool is enabled only when a single room is selected.

Custom Block Editor, Importing Data from a CADD File

A handy feature of HomeEnergy is the ability to import data from CADD files. This is a two-step process. The first step is to use a CADD program to create the information you will import. The second step is to import the data into HomeEnergy.

***Preparing CADD Data for Importing*.** You can use any CADD program as long as it has the capability to save data as a DXF (ASCII Drawing Exchange Format) file. The following procedure is recommended in preparing CADD data for importing to HomeEnergy.

1 Create a layer in your CADD drawing file for each block you want to import to HomeEnergy. Give these layers names that will make sense to you later. An example layer name is 1stFlrZns.

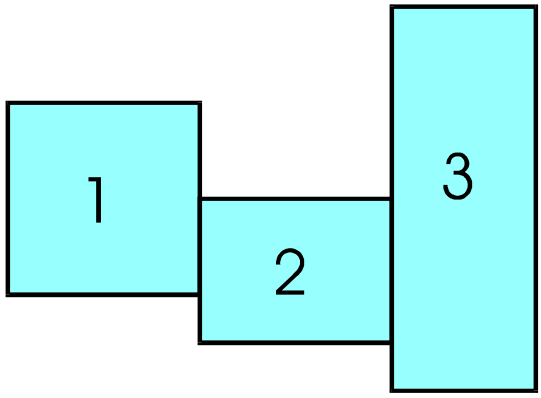
2 On each layer, draw a group of contiguous closed polygons. Each polygon represents a room in your energy model. When you create the closed polygons, make sure that you honor the custom block rules and restrictions.

3 Save your CADD file using an ASCII DXF format. Depending on the units you used to create your CADD drawing, you may want to set a scale factor as you save your DXF file. It is best that the units in your DXF file match the units you are using in HomeEnergy, either feet or meters.

Importing Data to HomeEnergy. Once you have prepared you CADD file, you can import the data to HomeEnergy. To do so, carry out the following steps

	Step	HomeEnergy Response
1	Choose and then DXF.	Additional controls will appear on the right side of the Custom Block Editor form. These will include list boxes for Layers and Polygons and four command buttons with the captions Open DXF File, Add to Model, Scale Factor, and Leave DXF.
2	Click the Open DXF File command button to open a CADD file.	The common dialog box will appear. Choose a DXF file and click Open. HomeEnergy will then attempt to read the file you selected. If it is successful, the Layers list box will be filled with the layers that appear on the file.
3	Click the DXF Scale Factor command button if needed to set the conversion factor for importing data.	HomeEnergy uses either feet or meters, depending on whether you are working with SI units. The CADD file, however, can use inches, millimeters, or any other units. The scale factor converts the units used on the DXF file to either feet or meters.
4	Click on the layer that has the closed polygons that you want to import.	An outline of all the closed polygons on the layer will be displayed in the drawing space. The Polygons list box is updated to show the closed polygons located on the layer you just selected. These are labeled Polygon1, Polygon2, etc.
5	Click on one of the polygons	The selected polygon is highlighted.
6	Click the Add to Model command button	The selected polygon is added to the block as a room. When the polygon/zone is added, HomeEnergy will check to see that the rules and restrictions have been honored. If they have, HomeEnergy will add the room to the block.
7	Repeat steps 5 and 6 until you have completed construction of your custom block	An image of your block will be shown in the drawing area.

You may notice that when you select a layer, the caption reads “Add All”. If you click this command button before selecting a polygon, HomeEnergy will attempt to add all the polygons to the model, essentially, repeating steps 5 and 6 described above. When adding zones from a CADD file, you must add them such that the rules and restrictions are honored at each step along the way. If you have three zones that are side by side as shown below. You can add 1, then 2, then 3, but you cannot add 1 followed by 3, because 1 and 3 by themselves would violate the custom block rules and restrictions. The “Add All” option looks for optional sequences of adding the rooms so that the rules are not violated at each step.



Rules and restrictions for adding a zone

The following rules must be followed when creating a custom block.

1 The rooms that make up the block must be contiguous and together they must form a regular polygon, e.g. the overall block polygon may have no holes.

2 Vertices that define adjacent zones must align with each other perfectly. To achieve this, it is helpful to choose Options|Snap to Vertices or Snap to Line.

Custom Block Editor, Toolbar Reference

The Custom Block Editor tool bar is used for just about all the drawing functions. Tools are used to zoom and pan the drawing, to add rooms, to move or delete vertices and to perform other functions. The Custom Block Editor tools are described below.

Select Room. Use this tool to select one or more rooms. Other toolbar buttons are enabled or disabled depending on the number of rooms that are selected. For instance, the Delete Room tool is enabled only when a single room is selected. The Combine Rooms toolbar button is enabled only when two and only two rooms are selected.

Select Vertex. Use this tool to select a vertex. You must select a vertex before it can be deleted. The Delete Vertex toolbar button is not enabled unless a vertex is selected. Only one vertex can be selected at a time. When you select a new vertex, the one that was previously selected (if any) is unselected.

Zoom. This toolbar button causes the Zoom toolbar to “flyout” so you can select how you want to zoom the drawing. The zooming choices are shown below:

Zoom In. Use this tool to zoom in on a portion of the drawing. Drag the mouse pointer over the area that you want to zoom to and release the button.

Zoom Out. This tool zooms out to the previous view. If there are no previous views, then one grid spacing is added in each direction.

Zoom Extents. This tool zooms so that the extents of the drawing are contained within the visible drawing space.

Add Room. This toolbar button is used to add new rooms to the block you are editing. It causes the Add Room toolbar to "flyout" so you can choose a method of adding a room. You can add a room by drawing a two-point rectangle or a polygon. You can also enter the vertices of the new room or import data from CADD files. With all methods, the process is to create rooms, one-by-one, and merge them into the block. If the process is not successful, a message will be displayed explaining the problem. These alternative methods for adding rooms are described below in greater detail.

Add Room Rectangle. With this tool, you add a room to the model by dragging the mouse to define a two-point rectangle. When you select the tool, the mouse cursor changes to show you that you are defining a two-point rectangle. Press the left mouse button to set the first point of the rectangle. Hold down the mouse button and drag to the second point. When you release the mouse, HomeEnergy attempts to merge the new room into your block. If Snap-to-Grid is turned on, the points will be forced to the nearest snap coordinate.

Add Room Polygon. With this tool, you define a room by setting the vertices of a general polygon by clicking with the mouse. The polygon method allows you to define rooms with more complicated geometry. When you have entered the last vertex, click once with the right mouse button to close the polygon. If Snap-To-Grid is turned on, then each vertex you set will be forced to the nearest snap coordinate.

Add Room Coordinates. When you select this tool, a spreadsheet appears on the right side of the form where you can enter the coordinates of a new room and the coordinates of the daylight reference point(s). Use the arrow keys or the mouse to move from cell to cell in the spreadsheet. Use the Insert Row command button to add a row (vertex) to the table. When you have finished entering the coordinates, click the Accept command button to add the room to the model. Snap-to-Grid has no effect when entering the coordinates of a new room.

Add Room DXF. Use this tool when you want to import data from a CADD file. Some new controls appear on the right side of the form that allow you to Open DXF File, if one is not already open. When a DXF file is opened, the Layers list box will display the layers that are contained in the file. When you choose a layer, all the closed polygons on that layer are displayed on the drawing. The polygons are also shown in the Polygons list box. When you select a polygon, it is shown highlighted. Click the Add Poly command button to add the selected polygon to the model. The Scale Factor command button is used to set the conversion factor between the units used in the CADD file to those used in HomeEnergy.

Edit Room Vertices. This toolbar button is used to edit the vertices of the selected room. This toolbar button is enabled when one and only one room is selected. When you use this tool, the coordinates of the selected room are displayed in a spreadsheet like control on the right side of the form. You can then change the coordinates by typing over the coordinates that are displayed. This option works in a manner similar to entering a room by entering X-Y coordinates.

Room Delete. This toolbar button is used to delete the selected room. This toolbar button is enabled when one and only one room is selected. A room can be deleted only when the custom block rules are not violated. If the function is not successful, a message is displayed describing the problem

Room Combine. This toolbar button is enabled when two rooms are selected. HomeEnergy attempts to combine the two selected rooms. If the function is not successful, a message is displayed describing the problem. Rooms can be combined only if they are adjacent.

Block Rotate. This toolbar button enables you to rotate the block. You cannot rotate individual rooms, only the whole block. Rotating a block is a two-step operation. First you set the pivot point by clicking with the left mouse button. After that, you drag with the left mouse button to rotate the block. When the block is in the position you want, release the button.

Block Move. Use this tool to move the block to a new location. The cursor changes to show that you are moving the block. Hold the left mouse button down and drag the block to the new location. If Snap-to-Grid is on, then the block is moved in snap increments.

Delete Vertex. This tool is used to delete the selected vertex. It is enabled only when a vertex is selected. It is necessary to first

Move Vertex. This tool is used to move a vertex to a new location. Click with the left mouse on the vertex that you want to move and drag it to the new location.

Move Daylight Reference Point. This tool is used to position the daylight reference points. First select a room. The daylight reference points for the selected room will then be displayed and the room itself will be highlighted. If the reference points are located on top of each other it will appear that there is only one. If you drag one to the side, it will expose the other. Each room has two reference points. The first is shown in the highlight color and the second is shown white. The reference point is assumed to be 2.5 ft above the floor.

Insert a New Vertex. This tool is used to insert a new vertex. Click on a line segment where you want to insert a new vertex.

Snap Settings. The snap settings are CADD features that allow you to construct you model with greater precision. This toolbar button causes additional toolbar buttons to “flyout” so that snap options can be turned on or off. The following options are available.

Snap Angle. This toolbar button is used to set the snap angle to use when rotating a block. The snap angle is ignored if Snap-to-Grid is not turned on. When on, the Block Rotation function jumps to the nearest snap angle. [

Snap-to-Grid On. This control turns Snap-to-Grid on. When on, the mouse cursor sets vertices at the nearest snap point. To change the snap point settings, click the Grid Setup toolbar button.

Snap-Off. Turns off both Snap-to-Grid and Snap-to-Vertex.

Snap-to-Vertex On. This toolbar button turns Snap-to-Vertex on. When on, the mouse cursor jumps to the nearest vertex. This mode is useful when you need to enter the vertices of a room that exactly align with an adjacent room.

Color Setup. This toolbar button opens the Color Settings form. Use this tool to choose the colors to be used on the form. The form that is launched is the same as the one that is launched from the Graphic Editor and from other places.

Display Grid. This toolbar button toggles display of the grid lines.

Grid Setup. This toolbar button opens the Grid Settings form. Use this tool to change the snap to grid settings. The form that is launched is the same as the one that is launched from the main form and from other places.

Project Files

As you define your house using HomeEnergy and make DOE-2 simulations, a variety of files are created, each contains information about your project. The files all begin with the name you used to identify your project, e.g. "MyJob." The file extension tells you the type of information contained in the file. Files types are summarized below and discussed in greater detail in the paragraphs that follow.

Table 6 Project files

File Type	Created with **HomeEnergy**
Project Files	MyJob.HES
INPut Files	MyJob.**I**xx
BDL Files	MyJob.**B**xx
OUTput Files	MyJob.**O**xx
Hourly **R**eport Files	MyJob.**H**xx
Batch File	MyJob.BAT
Project Log file	MyJob.LOG
Error File	Errors.Log

The **Project Files** have the extensions HES when created through the HomeEnergy program. These are binary files that contain all the information you entered through HomeEnergy. These files also include a summary of the simulation results so that the HomeEnergy reports can be generated. These files may only be opened by HomeEnergy.

Input files (INP) are created for your base case and for each alternative. Input files created through the HomeEnergy have the extension "I" followed by numeric characters "xx". The numeric characters indicate the base case or alternative. These files contain the information that is processed by DOE-2 to perform the simulation. The input files are text files that you can open, review, and modify with a text editor. If you are new to DOE-2 or have only used it with HomeEnergy, you should not modify these input files.

The **Building Design Language (BDL)** files contain similar information as the input files. However, these files are produced by DOE-2 after the INP files is read and contains some diagnostic information that you should review in evaluating your results. These are text files that can be opened and reviewed by any text processor. When reviewing, it is a good idea to search through the file for the text "WARNING" and/or "CAUTION". Review these messages if they exist to determine if there is a possible problem. If your simulation fails, the

BDL file will also contain “ERROR” messages that you should review to determine the nature and cause of the failure.

When your simulation is successful, one or more **Output (OUT) Files** will be created. These contain the results of your simulations. The output files are text files created by DOE-2. You can look at them and print them out using any text processor. For best results choose an 8 point nonproportional font such as Courier and print in landscape mode. The DOE-2 reports that are included in the output files depend on what you selected in Run Setup. These files can become quite large, especially if you call for a great number of reports, so you will need to watch disk space.

MyJob.BAT is a batch file which runs DOE-2 with the weather file you selected. This file is created by HomeEnergy each time you run a simulation. If you need to repeat the simulation, you can run this batch file. If you make a run outside of HomeEnergy, however, the HomeEnergy project file will not be updated with the results.

MyJob.LOG is a log of all the simulations you have made or attempted to make for the project. This file gives the time required for each part of the simulation and will report other problems.

The **Errors.Log** file is created when program errors occur. This file is not project specific, it includes errors that occurred with any project run with the installation of the program.

Diagnose Results

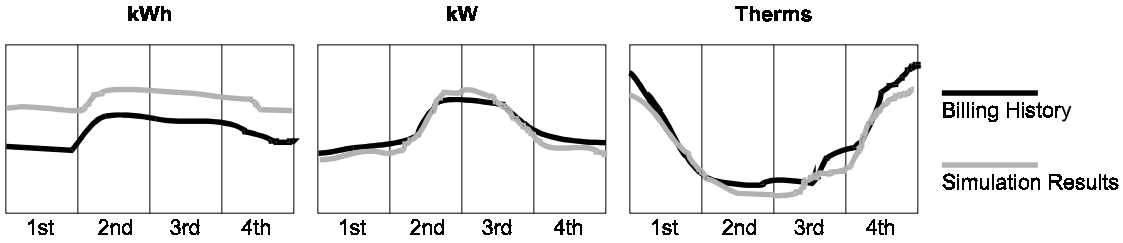
There are many reasons why the energy predicted in your model may not match the billing history. Here lists some common patterns of deviation between monthly data and simulation results. For each pattern, some suggestions are offered on how to better calibrate the base case model.

Pattern A

With this pattern, both peak electricity (kW) and gas use (therms) predicted by the simulation tool agree reasonably well with the billing history. However, electricity use predicted by the simulation tool is high relative to the billing history.

Possible Remedy

Adjust the simulation schedules to increase lighting and equipment hours at nights and weekends. This is a common problem with using the ASHRAE schedules, since they frequently under-predict off-hours lighting and equipment use.

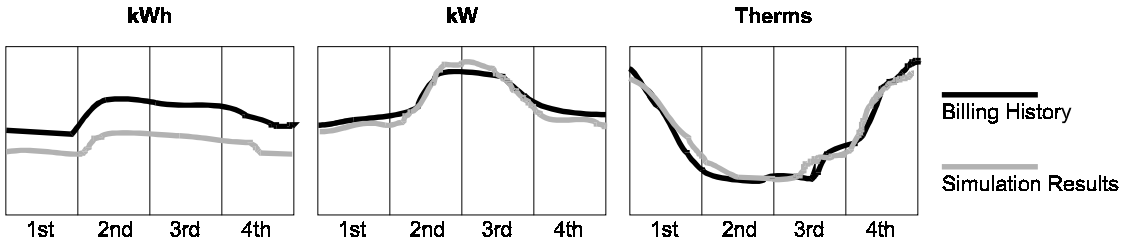


Pattern B

This is the opposite of Pattern A. Both peak electricity (kW) and gas use (therms) predicted by the simulation tool agree reasonably well with the billing history. However, electricity use predicted by the simulation tool is low relative to the billing history.

Possible Remedy

Adjust the simulation schedules to reduce lighting and equipment hours at nights and weekends.

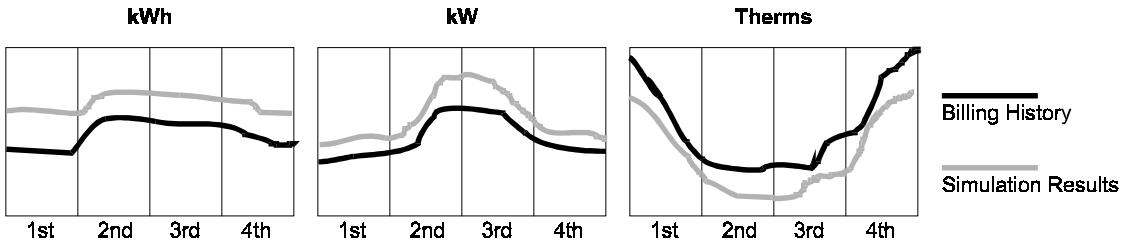


Pattern C

Both electric energy and demand predicted by the simulation tool are higher than the billing history, but predicted gas use is lower than the billing history.

Possible Remedy

Reduce lighting and/or equipment power in the simulation model. This will reduce electric energy and demand, reduce cooling loads and increase heating loads (as internal gains are reduced).

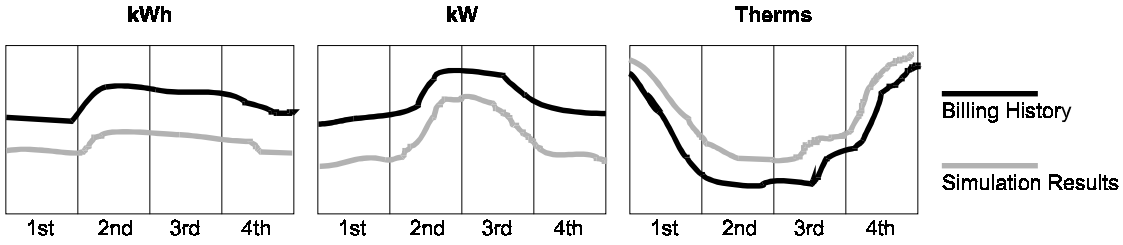


Pattern D

This is the opposite of Pattern C above. Both electric energy and demand predicted by the simulation tool are lower than the billing history, but predicted gas use is higher than the billing history.

Possible Remedy

Increase lighting and/or equipment power in the simulation model. This will increase electric energy and demand, increase cooling loads and reduce heating loads (as internal gains are increased).

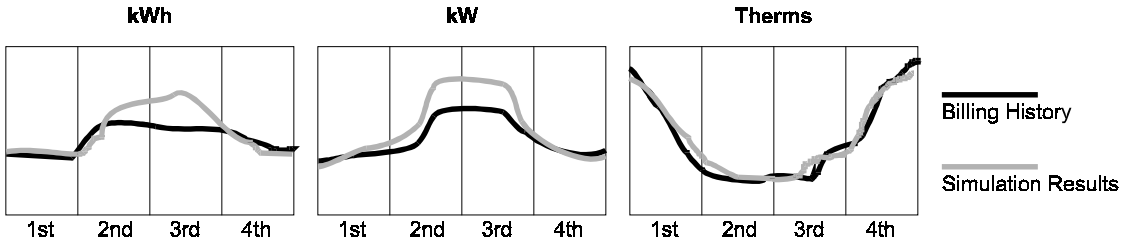


Pattern E

With this pattern, gas use predicted by the simulation tool agrees reasonably well with the billing history, but both kW and kWh are high during the summer months. In the winter, kW and kWh agree with the billing history.

Possible Remedy

Increase the efficiency of the cooling equipment in the simulation model. Check the performance data for the equipment in the model.

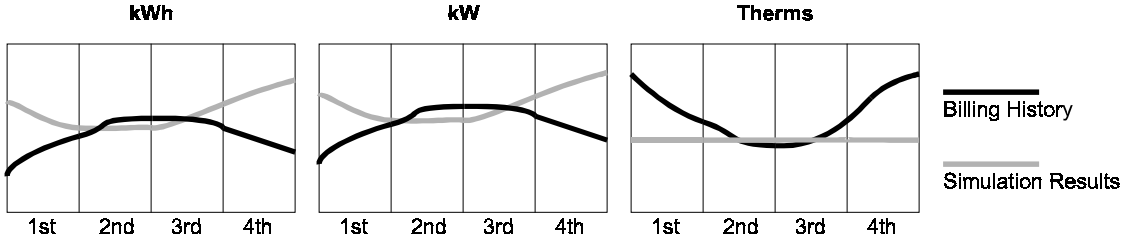


Pattern F

Both electric energy and demand predicted by the simulation model are high in the winter, but in reasonable agreement in the summer. Predicted gas use is relative constant throughout the year while the billing history is higher in the winter.

Possible Remedy

The simulation model has electric space heat while the actual building has gas heat. Check building survey information.

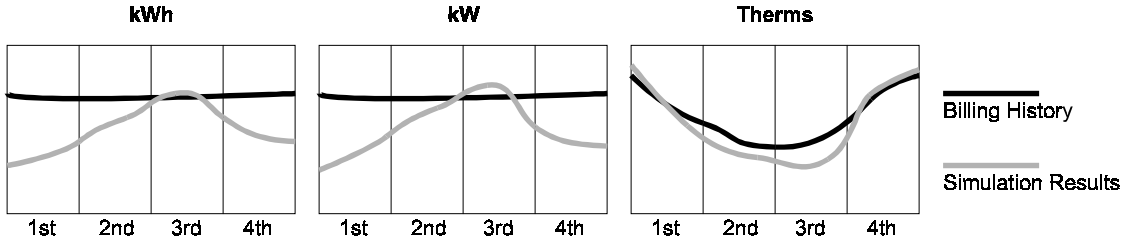


Pattern G

The billing history shows flat kWh and kW throughout the year while the simulation tool predicts significantly lower kW and kWh in the winter. The simulation tool predicts less gas use in reasonable agreement with the billing history.

Possible Remedy

An air economizer is operating in the simulation model, but it either does not exist or is malfunctioning in the actual building.

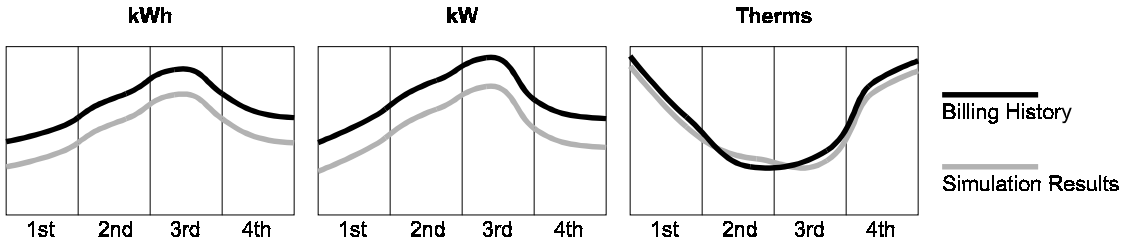


Pattern H

The simulation tool under predicts both electric energy and demand, but gas use is in reasonable agreement.

Possible Remedy

Check to see that all electric energy uses are included in the model. In particular look at elevators, exterior lights, etc.

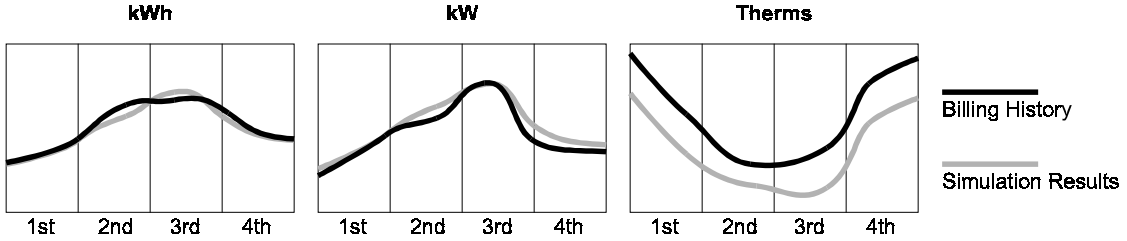


Pattern I

Electric energy and demand are in good agreement, but the simulation tool predicts less gas use than indicated by the billing history. The difference is fairly uniform throughout the year.

Possible Remedy

Water heating energy or other "constant" gas uses are being under-predicted. Adjust the efficiency of the water heating equipment, adjust the peak water heating use or adjust the schedule for water heating consumption.

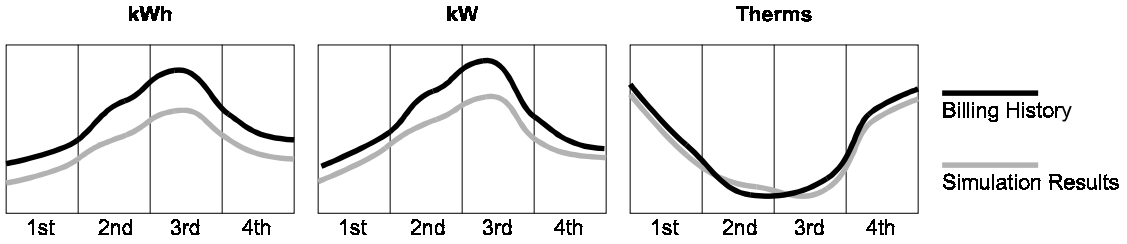


Pattern J

Gas use predicted by the simulation tool agrees with the billing history, but the tool under-predicts both electric energy and demand. The differential is greater in the summer.

Possible Remedy

The cooling capacity in the simulation model may be undersized. Check to see that loads are being satisfied for all periods of time.

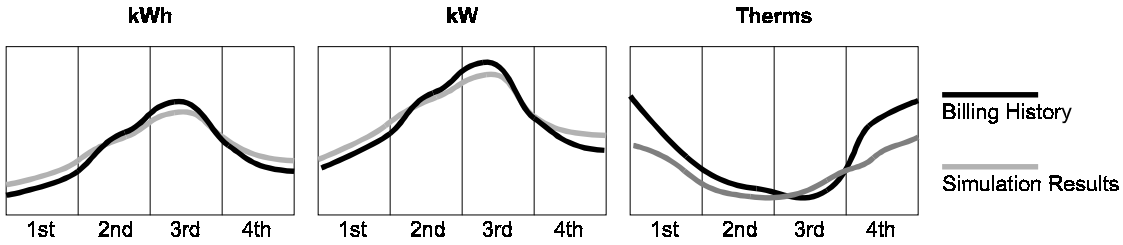


Pattern K

The simulation model under-predicts gas use, more in the winter than in the summer. The model also under-predicts both kW and kWh. The kWh differential is greater in the winter.

Possible Remedy

Check to see if the heating equipment in the model is adequately sized. Undersized equipment would explain this pattern.

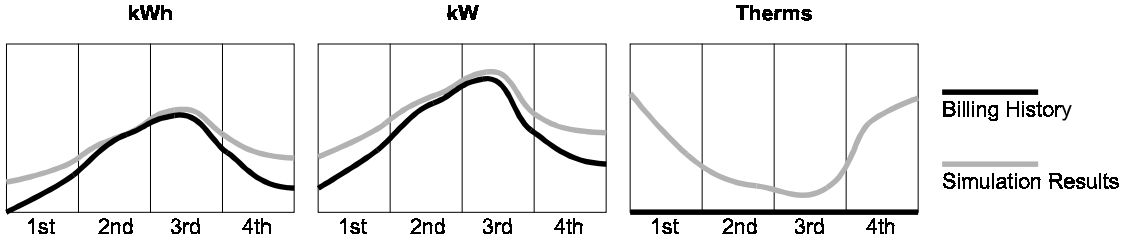


Pattern L

The simulation model predicts electric energy and demand fairly well in the summer months, but under-predicts in the winter. The model over-predicts gas use throughout the year, with the differential increasing in the winter month.

Possible Remedy

Check the heating system in the model. It appears that the building might be all electric, while the model has a gas heating system.

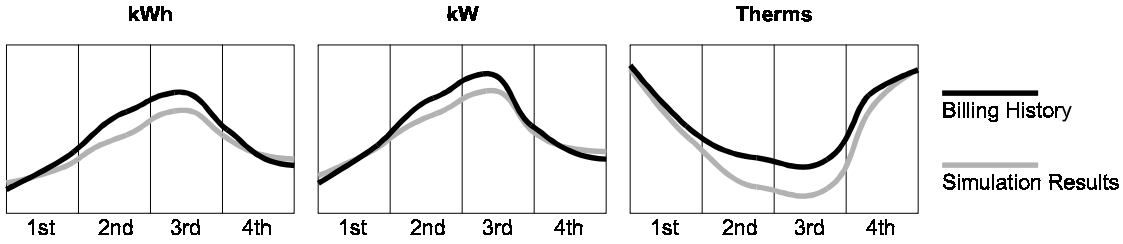


Pattern M

kWh, kW and Gas are too low in summer, but these agree with the billing history in the winter .

Possible Remedy

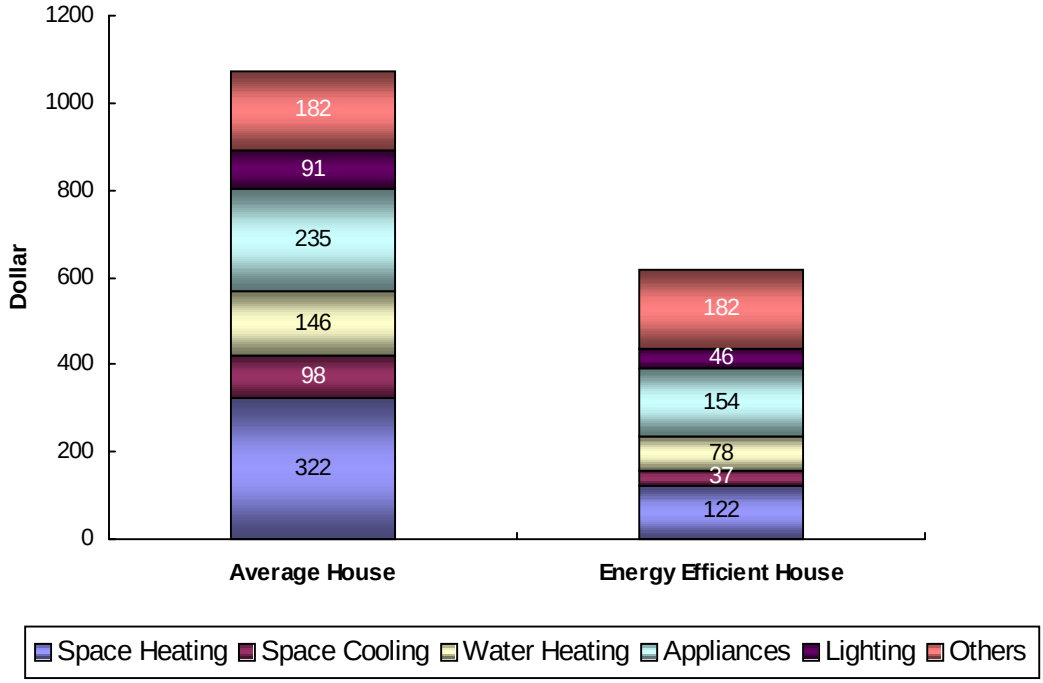
The reheat energy may be too low. The correct this, either lower the cooling supply air temperature, increase the minimum on the VAV boxes or change the supply air temperature reset schedule.



Energy Efficient Measures

The typical U. S. family spends about $1,300 a year on their home's utility bills. According to Energy Information Administration Residential Energy Consumption Survey 1997, the profile of energy consumption of an average house is, Refrigerators 12.9%, Air-Conditioning 11.8%, Space Heating 11.4%, Water Heating 11%, Lighting 9.2%, Other Appliances 43.8%. By using a few inexpensive energy-efficient measures, the energy bills can be reduced by 10% to 50%. As an example, the following figure shows the energy cost of a typical house and an energy efficient house in San Francisco area.

Figure 47 Energy bill of an average house vs an energy efficient house



Energy-efficient improvements not only make your home more comfortable, they can yield long term financial rewards while reducing outside air pollution. Potential energy savings come from improvements of the following areas.

- **Building Shell**

Add more insulation level of your exterior and basement walls, ceilings, attic, floors, and crawl spaces. Check for holes or cracks around your walls, ceilings, windows, doors, light and plumbing fixtures, switches, and electrical outlets that can leak air into or out of your home. Check for open fireplace dampers. Use windows with double panel, low-E glass, wood or vinyl frames, shading devices. Dependent on geographic area, plant trees to shade your house.

- **Heating and Cooling**

Use Energy Star-labeled equipment models. Use programmable thermostat adjusting heating and cooling temperatures at night or times when your home is unoccupied. Insulate and seal air ducts. Clean ware-air registers, baseboard heaters, radiators, and filters on furnaces. If appropriate, use heat pump systems. During summertime, use natural ventilation or fans to cool the indoor air.

- **Water Heating**

Use Energy Star-labeled water heaters. Insulate water heater/tank. Lower hot water temperature setting. If appropriate, use solar water heaters.

- **Lighting**

Replace high use lights with fluorescent or compact fluorescent fixtures. Turn off lights when no use. Use skylight if possible.

- **Appliances**

Use Energy Star-labeled appliances including TVs, VCRs, computers, refrigerators, dish washers, clothes driers, audio systems, fax machines, printers, ovens etc. Turn off appliances when no being used.

Technical Support

Email support is available for both versions while phone support is only for the licensed HomeEnergy Professional version. Technical questions should be addressed to:

Tianzhen Hong or Charles Eley

Eley Associates

142 Minna Street

San Francisco, CA 94105

Phone: 415-9571977; Fax: 415-9571381

Email: support@eley.com

Web: www.eley.com

Latest updates of HomeEnergy can be automatically downloaded by running the GDTLiveUpdate program. Its installation program can be downloaded from http://www.eley.com/gdt/downloads/GDTLiveUpdateSetup.exe.

Program Limitations

HomeEnergy version 1.0 has some limits and simplifications as follows,

- Maximum number of stories is 3

This can be easily extended to more than 3.

- No slope roofs

As VisualDOE 3.0 foundation classes do not support slope surfaces, some work around need to be done.

- Only one construction type of roof and floor

More than one construction type of roof and floor can be easily implemented if necessary.

- Air duct modeling is simplified as a correction factor on the efficiency of heating and cooling system

As the simulation engine DOE-2.1E version 110 from LBNL is not capable of modeling air ducts, some research suggest using empirical functions, derived from experiments and analysis, in DOE-2 input files.

- Doors have to be modeled as walls

Appendix - HomeEnergy Reports

Name: House 6557413
Description: This house is used to demonstrate the proposed user interface for the residential energy analysis tool being developed through PIER II funding. ##SAMPLE##
Analysis done by: Eley Associates
Gross Area: 2,812 ft²
Project File: c:\temp\house1.hes
Library File:
Case Name: Simulation
Case Description:
Number of Blocks: 2

Block 1, Level 1: first floor

Block Information		Ceiling and Plenum Heights	
Shape	RECT	Floor to Floor Height	10 ft
Zoning	Custom	Number of Floors	1
Zone Depth	10 ft		
Number of Zones	2		
Number of Facades	4		

Block Dimensions

Coordinates (ft)		Widths (ft)		Depths (ft)	
X	0	Width	30	Depth	28
Y	0	W2	50	D2	50
Z	0				

Block Constructions

Construction	Description	U-Factor (Btu/h-ft²-F°)	Heat Cap. (Btu/lb-F°)
Roof	ResSimpleRoof	0.000	0.0
Ceiling	Asm93	0.100	0.0
Floor	HES-Slab	0.028	45.7
Int. Floor	ResIFloor	0.100	0.0
Interior Wall	ResPartition	0.100	0.0

Facade Dimensions

Name	Bay Width (ft)	Fraction of Bays With Windows	Window Height (ft)	Window Width (ft)	Partial Window
B1 back	Custom	n/a	3	4	No
B1 back	Custom	n/a	3	4	No
B1 back	Custom	n/a	3	4	No
B1 back	Custom	n/a	3	4	No
B1 left	Custom	n/a	3	4	No
B1 left	Custom	n/a	3	4	No
B1 front	Custom	n/a	3	4	No
B1 right	13	1	3	4	No

Facade Shading

Name	Window Recess (ft)	Interior Shading	Exterior Shading	Overhang Distance (ft)	Overhang Projection (ft)	Side Fin Distance (ft)	Side Fin Projection (ft)
B1 back	0			n.a.	n.a.	n.a.	n.a.
B1 back	0			n.a.	n.a.	n.a.	n.a.
B1 back	0			n.a.	n.a.	n.a.	n.a.
B1 back	0			n.a.	n.a.	n.a.	n.a.
B1 left	0			n.a.	n.a.	n.a.	n.a.
B1 left	0			n.a.	n.a.	n.a.	n.a.
B1 front	0			n.a.	n.a.	n.a.	n.a.
B1 right	0			n.a.	n.a.	n.a.	n.a.

Facade Constructions

Name	Window Construction	U-Factor (Btu/h-ft²-F°)	SC	VLT	Wall Construction	U-Factor (Btu/h-ft²-F°)	HC (Btu/lb-F°)
gWallLeft	n.a.	n.a.	n.a.	n.a.	Wd. Frm. 16" o.c. R-0	0.093	0.2
gWallRight	n.a.	n.a.	n.a.	n.a.	Wd. Frm. 16" o.c. R-0	0.093	0.2
gWallFront	n.a.	n.a.	n.a.	n.a.	Wd. Frm. 16" o.c. R-0	0.093	0.2

B1 back	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 back	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 back	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 back	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 left	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 left	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 front	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 right	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2

Skylight Information

Name	Width (ft)	Height (ft)	Depth (ft)	Window Construction	U-Factor (Btu/h-ft²-F°)	SC	VLT

Name: House 6557413
Description: This house is used to demonstrate the proposed user interface for the residential energy analysis tool being developed through PIER II funding. ##SAMPLE##
Analysis done by: Eley Associates
Gross Area: 2,812 ft²
Project File: c:\temp\house1.hes
Library File:
Case Name: Simulation
Case Description:
Number of Blocks: 2

Block 2, Level 2: second floor

Block Information		Ceiling and Plenum Heights	
Shape	RECT	Floor to Floor Height	10 ft
Zoning	Custom	Number of Floors	1
Zone Depth	10 ft		
Number of Zones	1		
Number of Facades	4		

Block Dimensions

Coordinates (ft)		Widths (ft)		Depths (ft)	
X	0	Width	30	Depth	28
Y	19	W2	50	D2	50
Z	10				

Block Constructions

Construction	Description	U-Factor (Btu/h-ft²-F°)	Heat Cap. (Btu/lb-F°)
Roof	ResSimpleRoof	0.000	0.0
Ceiling	Asm93	0.100	0.0
Floor	ResSimpleFloor	0.000	0.0
Int. Floor	ResIFloor	0.100	0.0
Interior Wall	ResPartition	0.100	0.0

Facade Dimensions

Name	Bay Width (ft)	Fraction of Bays With Windows	Window Height (ft)	Window Width (ft)	Partial Window
B1 left (2nd)	Custom	n/a	3	4	No
B1 left (2nd)	Custom	n/a	3	4	No
B1 left (2nd)	Custom	n/a	3	4	No
B1 back (2nd)	Custom	n/a	3	4	No
B1 back (2nd)	Custom	n/a	3	4	No
B1 back (2nd)	Custom	n/a	3	4	No
B1 right (2nd)	Custom	n/a	2.9	1.15	No
B1 front (2nd right)	Custom	n/a	3	4	No
B1 front (2nd right)	Custom	n/a	3	4	No
B1 front (2nd, middle)	Custom	n/a	3	4	No
B1 front (2nd)	Custom	n/a	3	4	No
B1 front (2nd)	Custom	n/a	3	4	No

Facade Shading

Name	Window Recess (ft)	Interior Shading	Exterior Shading	Overhang Distance (ft)	Overhang Projection (ft)	Side Fin Distance (ft)	Side Fin Projection (ft)
B1 left (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 left (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 left (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 back (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 back (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 back (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 right (2nd)	0			n.a.	n.a.	n.a.	n.a.

B1 front (2nd right)	0			n.a.	n.a.	n.a.	n.a.
B1 front (2nd right)	0			n.a.	n.a.	n.a.	n.a.
B1 front (2nd, middle)	0			n.a.	n.a.	n.a.	n.a.
B1 front (2nd)	0			n.a.	n.a.	n.a.	n.a.
B1 front (2nd)	0			n.a.	n.a.	n.a.	n.a.

Facade Constructions

Name	Window Construction	U-Factor (Btu/h-ft²-F°)	SC	VLT	Wall Construction	U-Factor (Btu/h-ft²-F°)	HC (Btu/lb-F°)
B1 left (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 left (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 left (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 back (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 back (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 back (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 right (2nd)	Double Clear 3/12/3 mm	.491	0.89	0.812	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 front (2nd right)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 front (2nd right)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
2flrWallintR	n.a.	n.a.	n.a.	n.a.	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 front (2nd, middle)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
2flrWallintL	n.a.	n.a.	n.a.	n.a.	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 front (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2
B1 front (2nd)	Default Window Glass (Single, Clear)	.0	0.00	0.00	Wd. Frm. 16" o.c. R-13	0.093	0.2

Skylight Information

Name	Width (ft)	Height (ft)	Depth (ft)	Window Construction	U-Factor (Btu/h-ft²-F°)	SC	VLT

HomeEnergy Architectural Summary April 6, 2001

Name: House 6557413
Description: This house is used to demonstrate the proposed user interface for the residential energy analysis tool being developed through PIER II funding. ##SAMPLE##
Analysis done by: Eley Associates
Project File: c:\temp\house1.hes
Library File:
Case Name: Simulation
Case Description:
Gross Area: 2,812 ft²
Number Floors: 2

Occupancy Summary

Name	Area (ft²)	Avg. LPD (W/ft²)	Avg. EPD (W/ft²)	No. of Occupants
Occupany Whole House	2,812	0.12	0.18	6.0
Building Totals & Averages	2,812	0.12	0.18	6.0

Constructions Summary

Name	Net Area (ft²)	U-Factor (Btu/h-ft²-F°)	Heat Cap. (Btu/lb-F°)	Absorp. %	Type	Category	Layers
ResIFloor	1,053	0.1	0.0	0.7		All	1
ResPartition	310	0.1	0.0	0.7	Partitions	All	1
ResSimpleRoof	1,759	0.0	0.0	0.7	Roofs	All	3
HES-Slab	1,759	0.03	45.7	0.0	Floors	Light	3
Wd. Frm. 16" o.c. R-13	2,479	0.09	0.2	0.7	Walls	Light	4
Wd. Frm. 16" o.c. R-0	690	0.09	0.2	0.7	Walls	Light	4

Fenestration Summary

Name	Ucog (Btu/h-ft²-F°)	SHGC	Tvis	North (ft²)	East (ft²)	South (ft²)	West (ft²)	Total (ft²)	No.
Default Opening	0.000	0.000	0.000	24	72	60	84	240	19
3x1.25 G1	0.491	0.762	0.812	3	0	0	0	3	1
Building Totals & Averages	0.007	0.010	0.011	27	72	60	84	243	20

Name: House 6557413
Description: This house is used to demonstrate the proposed user interface for the residential energy analysis tool being developed through PIER II funding. ##SAMPLE##
Analysis done by: Eley Associates
Project File: c:\temp\house1.hes
Library File:
Case Name: Simulation
Case Description:
Number of Blocks: 2

Zone Loads

Name	Area (ft²)	LPD (W/ft²)	EPD (W/ft²)	Occupancy	Occupant Density (ft²/person)	Daylight Control	Illuminance (fc)	Control Fraction	Infiltration (air-change/hr)
Garage	589	.12	.18	Occupany Whole House	466.7	None	n.a.	n.a.	0.2
1Floor	1170	.12	.18	Occupany Whole House	466.7	None	n.a.	n.a.	0.2
2Floor	1053	.12	.18	Occupany Whole House	466.7	None	n.a.	n.a.	0.2

Supply Air

Name	Total Flow (cfm)	Flow/Area (cfm/ft²)	Air change/hour	Min. Flow Ratio	Cap. (kBtu/hr) Cool/Heat	
Garage	AutoSized - 471	0	0	0		n.a.
1Floor	AutoSized - 775	0	0	0		n.a.
2Floor	AutoSized - 1017	0	0	0		n.a.

Outside Air

Name	Total Flow (cfm)	Flow(cfm)/Person	Air change/hour	Fraction Supply Air
Garage	n.a.	n.a.	n.a.	0.15
1Floor	n.a.	n.a.	n.a.	0.15
2Floor	n.a.	n.a.	n.a.	0.15

Name	**Thermostat** Type	Throttling Range (°F)	**PIU** Type	Zone Fan Volume (cfm)	Fan Power (bhp/cfm)
Garage	Proportional	5	No PIU	n.a.	n.a.
1Floor	Proportional	5	No PIU	n.a.	n.a.
2Floor	Proportional	5	No PIU	n.a.	n.a.

Exhaust Fans

Name	Method	Air Volume (cfm)	Power (bhp/cfm)	Static Pressure (in water)	Mechanical Efficiency	Drive Efficiency	Motor Efficiency

Name	**Zone Reheat** Reheat Delta-T (°F)	Heat Source	**Baseboards** Rating (kBtu/hr)	Control

Name: House 6557413
Address:
Description: This house is used to demonstrate the proposed user interface for the residential energy analysis tool being developed through PIER II funding. ##SAMPLE##
Analysis done by: Eley Associates
Project File: c:\temp\house1.hes
Library File:
Case Name: Simulation
Case Description:
System Number: 1
Name: Whole House System
System Type: Residential System

Heating

Supply Temperature		115 °F
Control	Constant	
Capacity (kBtu/hr)	Autosized	
Autosized Ratio	1.2	
Autosized Capacity		-114.19
Source	Furnace	

Furnace

Thermal Efficiency	0.68	
Auxillary Power (kW)		0
Pilot Light (Btu/hr)	0	

Supply Fan

(Included in EER/COP)

Fan Flow (cfm)		Autosized
Autosized Flow	1886	

Cooling

Supply Temperature		55 °F
Control	Constant	
Total Capacity (kBtu/h)		Autosized
Sensible Capacity (kBtu/h)		Autosized
Autosized Ratio	1.2	
Autosized Total Capacity		62.93
Dehumidification	none	
Coil Bypass Factor	0.001	
Energy Efficiency Ratio		9.35
Desuperheater		none
Evaporative Condenser		No
Water Cooled Condensor		No

Project Information
Name: House 6557413
Address:
Description: This house is used to demonstrate the proposed user interface for the residential energy analysis tool being developed through PIER II funding. ##SAMPLE##
Analysis done by: Eley Associates
SIC Code: 0
Gross Area: 2,812 ft²
Project File: c:\temp\house1.hes
Library File:
DOE-2 Version: DOE-2.1E110

Electrical Use Summary

Alternative	Lights	Equip.	Cooling	Pumps/Aux.	Fans	Ext. Lights	Total
Electrical End-use Totals (kWh)							
Simulation	1,972	2,870	2,501	125	579	219	8,266

Fuel Use Summary

Alternative	Heating	Hot Water	Ext. Equip.	Total
Fuel End-use Totals				
Simulation - Natural Gas (Therm)	426	187	74	687

Energy Cost Summary ($/y)

Alternative	Total Electric	Total Fuel	Total Utility
Total Energy Costs ($/y)			
Simulation	$909	$331	$1,240

* 20 year life cycle w/ 5% discount rate.

Monthly Electrical Usage (kWh)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Simulation	505	433	457	431	433	1,124	1,298	1,210	984	438	448	503

Monthly Electrical Power (kW)

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Simulation	1	1	1	1	1	5	6	6	5	2	1	1

Monthly Fuel Usage

Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
New Meter - Natural Gas (Therm)	127	80	45	20	8	6	6	6	7	13	55	126

Appendix III
Background Research

Background Research

Residential Energy Analysis Tool
CEC Contract # 500-98-025

Deliverable for Tasks 2.2.1 and 2.2.2

June 23, 1999

Prepared by:

142 Minna Street
San Francisco CA 94105

Executive Summary 1

***Energy Efficiency Measure Capabilities* 1**
Envelope 1
Heating and Cooling System 2
Water Heating 3
Other Miscellaneous 3

***Modeling Techniques* 4**
Zoning 4
Internal Gains 5
Slabs and Losses to the Earth 8
Crawlspaces 8
Basements 8
Garage and Other Unconditioned Space 8
Infiltration 8
Natural Ventilation 9
Mechanical Ventilation 9
Heat Recovery from Ventilation Air 9
Whole House Fan 9
Duct Losses 10
Shading from Adjacent Building 10
Interior Blinds and Drapes 10
Overhangs and Exterior Window Shades 11
Modeling Windows 11
Radiant Barriers 11
Reflective Roof Surfaces 11
Modeling Attics and Ceilings 11
Modeling Walls 11
Thermostat Schedules 12

***Equipment Performance* 13**
HVAC Systems 13
Water Heating Systems 13
ACM Water Heating Model 14
EPRI/LBNL Water Heating Models 14
DOE-2.2 Water Heating Model 15
Recommendations 17
Lighting 17
Household Appliances 17

***Operating Conditions* 19**

***Measured or Calibrated Data* 19**

REFERENCES 20

List of Tables

Table 1 – ACM Hourly Schedules 4
Table 2 – Monthly Internal Gain Adjustments 7
Table 3 –Distribution System Multipliers (DSMs) 14

List of Figures

Figure 1 – ACM Hourly Schedule of Internal Gains 6
Figure 2 – ACM Hourly Schedule of Internal Gains 7
Figure 3 – Part Load Curve for Gas Water Heater 16

Executive Summary

This report presents the findings of background research toward the development of a Windows based design and analysis tool for residential buildings that uses DOE-2.2 as the calculation engine. The tool will be simple enough for homeowners to use in evaluating proposals from energy service providers, while at the same time offering the power and detail needed by design professionals and product/equipment manufacturers. It will have the capability to model all aspects of residential energy use, including lighting (both interior and exterior), major appliances, miscellaneous equipment, air conditioning and heating equipment and domestic hot water. Interactions between these components are an integral part of the model.

The purpose of this task is to gather information which will be used to develop the software. Background research is conducted in four areas: modeling techniques, equipment performance, operating conditions and measured data. This preliminary report has information on modeling techniques and equipment performance. The other two topics will be addressed in a subsequent deliverable.

Energy Efficiency Measure Capabilities

This section lists the anticipated modeling and analysis capabilities of the software.

E n v e l o p e

- Attic insulation.
- Radiant barrier, attic installation
- Radiant barrier, wall or framed roof installation?
- Ceiling insulation, framed ceiling
- Wall insulation (including strawbale, rammed earth, engineered framing, and other unconventional constructions). Also include retrofit blow-in insulation, retrofit exterior rigid insulation. Wall exterior finish impact (stucco, wood, vinyl, shingle)?
- Raised floor insulation
- Slab-edge insulation
- Basement wall insulation
- Crawlspace wall insulation
- Roof albedo (abs and em)
- Wall albedo
- Skylight (heating and cooling impact)
- Window glazing and coatings
- Window frame
- Window gas fill
- Window retrofit film
- Window interior shades
- Window exterior shades
- Overhangs, eaves, sidefins

- Structure self shading
- Site shading (permanent and seasonal)
- Roof slope
- Attic ventilation (natural and mechanical)
- Natural ventilation (e.g. opening size and location, schedule, control)
- Infiltration reduction (blower door guided?)
- Thermal mass (heating and cooling impact)
- Sunspace?
- Air/Vapor barriers?
- Thermal mass (heating and cooling impact)

Heating and Cooling System

- Proper AC and heating equipment sizing? Heating and cooling load calculations!
- Duct testing and sealing
- Duct insulation
- Duct location
- Duct design?
- High efficiency AC
- Evaporatively pre-cooled condenser
- Equipment maintenance (AC, furnace, HP)?
- Efficient gas furnace
- Propane?
- Efficient heat pump
- Radiant baseboard heating
- Radiant floor heating
- Combined hydronic system (with baseboard, radiant floor, or fan coil)
- Multi-zone heating and cooling
- Multiple heating and cooling systems
- More detailed zoning; heating and/or cooling only portions of the home
- Ground-source heat pump?
- Programmable thermostat. Adjust setpoint and/or schedule
- Whole house fan
- Direct evaporative cooling
- Indirect/direct evaporative cooling
- Heat recovery from mechanical ventilation
- Other part-load efficiency measures? Multiple compressors, VSDs, Multi-speed fans

- Ceiling fans? Portable fans?
- Duct cleaning?

Water Heating

- Efficient gas water heater
- Propane?
- Heat pump water heater
- Water heater maintenance
- Large storage electric (with small heating element)
- Pipe insulation
- Heat trap
- Water heater jacket
- Instantaneous water heater
- Low flow showerhead
- Hot water storage temperature setpoint
- Location of water heater (conditioned or unconditioned space)

Other Miscellaneous

- Hardwired fluoresent lights
- Portable fluorescent lights
- Washing machine (horizontal axis or efficient vertical axis)
- Clothes dryer (electric vs gas)
- Pool cover?
- Efficient pool heater?
- Pool pump controls?
- Solar pool heating?
- Photovoltaics?
- Other appliance and equipment measures? (e.g. efficient refrigerator, gas cooking, smaller TV, energy star computer/printer/fax/copier)

Modeling Techniques

The purpose of this research task is to evaluate and recommend techniques for modeling residential buildings using DOE-2.2. There are many issues relating to the detail with which the model is constructed and how various energy conservation features are modeled. This section makes many references to the CEC's Residential ACM Approval Manual, which specifies calculation procedures and methods to be used by energy tools that are used either for Title 24 compliance or for home energy rating systems (HERS). This document is available from the CEC website at www.energy.ca.gov. We will refer to the document in this study as the "ACM." This section also makes reference to the DOE-2 documentation.

Z o n i n g

DOE-2.2 can model hundreds of thermal zones. However, the conditioned space in single family homes is typically modeled as a single thermal zone.[1] Greater accuracy can be achieved, however, by increasing the number of zones in the model. The conditioned space itself can be divided into separate thermal zones. This would be appropriate when the house is served by HVAC system(s) that are capable of maintaining different space temperatures. "Zonal" systems might include hydronic systems that use under floor radiant panels or baseboards. Zonal control can also be provided with air distribution systems that have dampers to isolate air flow to certain areas.[2]

Zonal control is an optional modeling capability in the residential ACM. When this feature is enabled, the sleeping and living areas of the house are modeled as separate thermal zones. The ACM specifies separate thermostat schedules and internal gain schedules for these separate zones. These are shown in Table 1.

Additional zones might include unconditioned spaces such as attics, crawlspaces and attached garages. Sometimes separate systems serve different areas of the building. Correctly modeling unconditioned spaces is important for a couple of reasons. First, the spaces provide a buffer between ambient conditions and the heated (and cooled) interior space. Second, HVAC ductwork is usually located in unconditioned spaces and the losses depend on the temperature of the space.

Recommendation. It is recommended that separate thermal zones be created for attics, crawlspaces and garages, when they exist. In the simplest case, the conditioned area may be a single zone served by a single system. However, the user may also specify multiple zones and multiple systems. If more than one zone is served by a single-zone system type (like RESYS), then the zone with the thermostat will be identified and the other zone will be indirectly controlled. Each zone and system may also operate on a different schedule. [We may want to allow each room to be specified separately, allowing load calculations by space]

Table 1 – ACM Hourly Schedules

	Heating Setpoint			Cooling Setpoint			Internal Gain Percentage		
Hour	Whole	Living	Sleeping	Whole	Living	Sleeping	Whole	Living	Sleeping
1	60	60	60	78	83	78	2.40	1.61	4.38
2	60	60	60	78	83	78	2.20	1.48	4.02
3	60	60	60	78	83	78	2.10	1.14	4.50
4	60	60	60	78	83	78	2.10	1.13	4.50
5	60	60	60	78	83	78	2.10	1.21	4.32
6	60	60	60	78	83	78	2.60	1.46	5.46
7	60	60	60	78	83	78	3.80	2.77	6.39
8	68	68	68	78	78	83	5.90	5.30	7.40
9	68	68	60	78	78	83	5.60	6.33	3.76

[1] This approach is taken by MICROPAS, CALRES, Comply 24, and other programs used for Title 24 compliance. Residential modeling studies conducted at the national laboratories also typically use this approach.

[2] The DOE-2.2 ResVVT system is an example of this type of system. See DOE-2.2 documentation.

10	68	68	60	78	78	83	6.00	6.86	3.85
11	68	68	60	78	78	83	5.90	6.38	4.70
12	68	68	60	78	78	83	4.60	5.00	3.61
13	68	68	60	78	78	83	4.50	4.84	3.65
14	68	68	60	78	78	83	3.00	3.15	2.63
15	68	68	60	78	78	83	2.80	2.94	2.46
16	68	68	60	78	78	83	3.10	3.41	2.32
17	68	68	60	78	78	83	5.70	6.19	4.47
18	68	68	60	78	78	83	6.40	7.18	4.45
19	68	68	60	78	78	83	6.40	7.24	4.29
20	68	68	60	78	78	83	5.20	5.96	3.30
21	68	68	60	78	78	83	5.00	5.49	3.75
22	68	68	68	78	78	78	5.50	6.20	3.75
23	68	68	68	78	78	78	4.40	4.38	4.45
24	60	60	60	78	83	78	2.70	2.35	3.59

Internal Gains

Heat gains from electric lights, appliances and other equipment is a significant factor in accurately modeling heating and cooling loads. Energy used by lights and appliances is also a significant factor that needs to be accounted for in any meaningful estimate of annual energy use. The residential ACM requires that residences be modeled with internal gains. The prescribed assumption is to consider a fixed amount of 20,000 Btu/day for each dwelling unit and to add another 15 Btu/day for each square foot of conditioned floor area. If the house is modeled with zonal control, the fixed component (20,000 Btu/day) goes to the living zone and the variable component is prorated by the conditioned floor area of each of the zones. See following equations.

$$\text{IntGain}_{\text{total}} = 20{,}000 + 15 \times \text{CFA}_{\text{total}}$$

$$\text{IntGain}_{\text{living}} = 20{,}000 + 15 \times \text{CFA}_{\text{living}}$$

$$\text{IntGain}_{\text{sleeping}} = 15 \times \text{CFA}_{\text{sleeping}}$$

The hourly schedule for this internal gain is shown in Table 1.

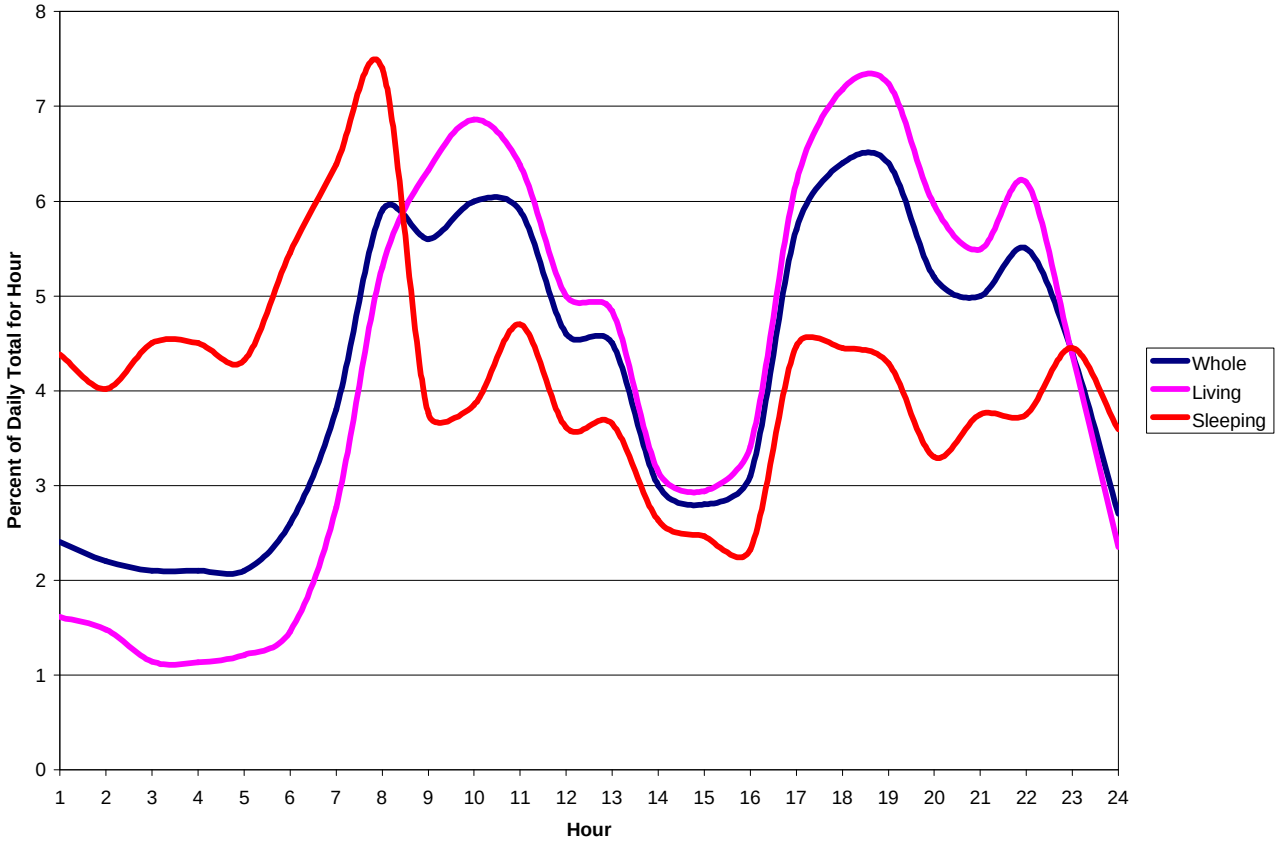


Figure 1 – ACM Hourly Schedule of Internal Gains

The ACM also requires that internal gain be adjusted on a monthly basis as shown in Table 2. These monthly multipliers modify the total daily internal gain.

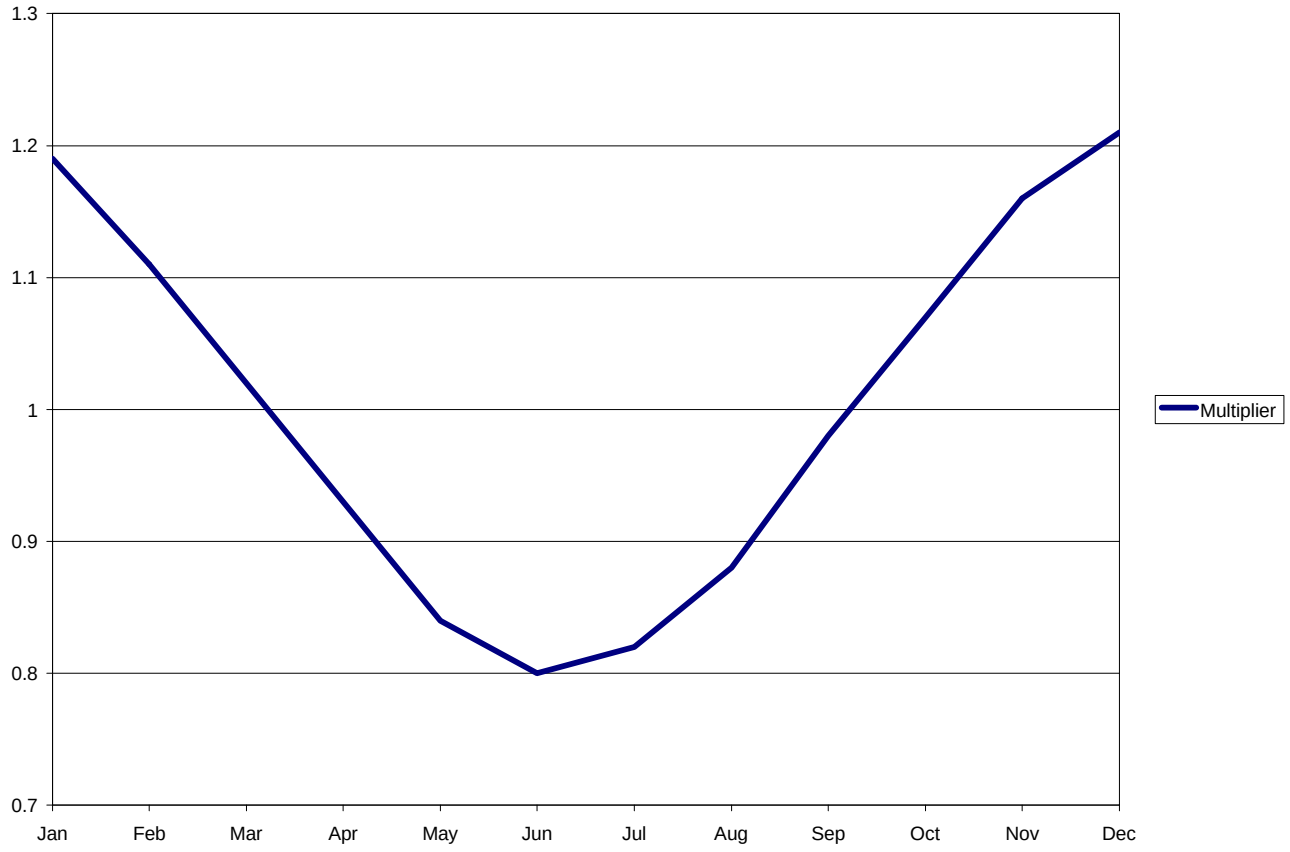


Figure 2 – ACM Hourly Schedule of Internal Gains

Table 2 – Monthly Internal Gain Adjustments

Month	Multiplier	Month	Multiplier
Jan	1.19	Jul	0.82
Feb	1.11	Aug	0.88
Mar	1.02	Sep	0.98
Apr	0.93	Oct	1.07
May	0.84	Nov	1.16
Jun	0.8	Dec	1.21

The ACM only considers energy uses that becomes heat within the space. Energy used by a clothes dryer, for instance, that is vented to the out-of-doors, is not considered. Nor is energy used by exterior lighting, pools, spas, etc. These energy uses are important to making a reasonable estimate of annual energy use, but are not important to accurate estimates of heating and cooling energy, which is what the ACM is concerned with.

DOE-2.2 allows the lighting and household appliances to be modeled through commands and keywords for miscellaneous equipment and lighting systems. Up to five lighting systems can be modeled in each space, each with its own schedule. In addition, each thermal zone can have miscellaneous electric energy use that can be scheduled. Also at the project level, both electric and gas energy can be scheduled which does not manifest itself as internal gains in one of the thermal zones.

Recommendation. Collect data on appliance energy use and saturation. Look in particular at the NEOS report done for the CEC. Also look at survey data from PG&E and SCE. The SCE data is cited in the California Lighting Model work we did with HMG. Contact Marian Brown at SCE for more information. Attempt to develop a model that will predict

Slabs and Losses to the Earth

The ACM Manual slab model is a perimeter one-foot high *exterior* wall with F2 values depending on insulation thickness, insulation depth, and floor covering (F2 values not specified, but Residential Manual table may be used). Required assumption is 80% of perimeter is carpeted and 20% uncovered. Slab adjacent to unconditioned space such as a garage is to be considered uninsulated exterior perimeter.

Studies have shown that using an *underground wall* construction is more accurate. [Bazjanac, 1996] evaluates three methods and compares them to a detailed finite difference model. Most effective method is to use underground floor with thermal mass and U-EFFECTIVE based on the F2 value for the perimeter. Essentially the same approach as Winkelman. See report for sample BDL.

Recommendation. Model slab with a one-foot layer of soil and a fictitious insulation layer underneath. Then use the U-EFFECTIVE keyword, basing the calculation on F2 value from a lookup table. Includes an extensive lookup table for slab floors, basement walls and crawlspace walls. See report for sample BDL. FLOOR-WEIGHT = 0 in space so that custom weighting factors are calculated [Winkelman, 1998]

BDL: to be completed.

Crawlspaces

ACM Manual represents a crawlspace as an R-6 layer in the floor construction rather than a separate thermal zone. It also allows for a controlled vent crawlspace, which is a separate zone that has insulation at the perimeter of the crawlspace and has vents closed during heating mode and open during cooling mode. Infiltration in the controlled vent crawlspace is assumed to be 0.22 air changes per hour when vents are closed.

Recommendation. Since DOE2 can model multiple zones, create a separate, unconditioned crawlspace zone. Model the crawlspace wall as an *underground* wall just as for slabs, using the F2 value to calculate U-EFFECTIVE. Model the floor of the crawlspace as an underground floor with high mass and high thermal resistance (R-1000). If more than 8 inches of crawlspace wall is above grade, then model it as a separate exterior wall. [Winkelman, 1998]. Model the floor between the conditioned space and the crawlspace as an interior wall with its actual construction. Do not model controlled vent crawlspaces since they are uncommon.

Basements

The ACM manual specifies outdoor temperature conditions to use for below-grade walls in three sections: for the first two feet, from two to six feet and below six feet. The temperatures are based on averages of past temperatures. This method cannot be implemented in DOE2 without a custom function. The exterior solar absorptivity must be zero.

Recommendations. Use the same method as described for crawlspaces above, except model it as a conditioned space if it is conditioned.

Garage and Other Unconditioned Space

Unconditioned space is not required by the ACM manual to be modeled as a separate thermal zone. Walls between conditioned and unconditioned space are considered to be exposed to outdoor temperatures and receive no solar gain. Slab floors next to unconditioned space are modeled as uninsulated perimeter.

Recommendation. Take advantage of DOE2's multi-zone capability and include separate unconditioned zones. Surfaces between conditioned and unconditioned zones are modeled as interior surfaces with their actual construction. Slabs that are continuous between conditioned and unconditioned zones are also considered interior walls with dimensions 3.5" high and 3.5" thick.

Infiltration

The ACM specifies the effective leakage area (ELA) method for infiltration. Default values are provided for two cases; homes with ducted systems and those without ducts. This method accounts for wind driven and

stack driven infiltration, although the inputs for height distance between inlet and outlet are restricted to three values for single-story, two story and three story homes.

DOE-2.2 has four alternative methods for modeling infiltration (from 3-Loads.pdf):

> AIR-CHANGE. The infiltration rate is calculated using the air-change method. AIR-CHANGES/HR or INF-FLOW/AREA should be specified if INF-METHOD = AIR-CHANGE. In this case the value AIR-CHANGES/HR will be corrected for wind speed each hour, but the value of INF-FLOW/AREA will not be corrected. If both AIR-CHANGES/HR and INF-FLOW/AREA are specified, the resulting infiltration rates are added.
>
> RESIDENTIAL. The infiltration rate is determined by the values of RES-INF-COEF and depends on wind speed and outside-inside temperature difference.
>
> S-G. Sherman-Grimsrud Infiltration Method. Applies only to single-zone. Uses keywords HOR-LEAK-FRAC, NEUTRAL LEVEL and FRAC-LEAK AREA.
>
> CRACK. In the case of the Crack Method, a value should be entered for the INF-COEF keyword in the EXTERIOR-WALL instruction, and for the keyword INF-COEF in the WINDOW instruction.

Recommendation. Use the Sherman Grimsrud method because it is accurate and is equivalent to the ACM method. (Question ➔ determine if there is a problem using S-G in multiple-zone models).

Natural Ventilation

The ACM method assumes that windows will be opened whenever the home feels "stuffy", which is defined as hours when infiltration drops below 0.25 air changes per hour. In the following hour, the program must add 0.35 air changes assuming that occupants open the windows.

Recommendation. Use the natural ventilation algorithm in DOE2. It allows specification of a schedule for times that windows would be opened and opens them if beneficial cooling is available. A probability can be entered for likelihood that the windows will be opened and closed. A temperature schedule defines the minimum indoor temperature where the windows will be closed by the occupants. The Sherman-Grimsrud infiltration method may be used to determine the ventilation air flow when the windows are open (air change method is also possible). Using the DOE2 algorithm limits the available system types to RESYS, RESYS2, PSZ, FNSYS1, and EVAP-COOL (and possibly PVAVS).

Mechanical Ventilation

The ACM requires that mechanical ventilation be assumed in homes with very low infiltration rates, effectively setting a lower floor on the air leakage rate.

Exhaust fans in DOE2 operate on the same schedule as supply fans, so it is not possible to have a 24 hour exhaust fan with an intermittent supply fan. RESYS does not allow any exhaust fan. One possibility is to set the infiltration to a specific air changes per hour value to represent mechanical ventilation, and the energy consumption of the fan would have to be entered as an external electricity use.

Recommendation. Allow user to enter air changes (or cfm) and watts for ventilation fan for one or more zones. Model as infiltration using the airchange method for those zones, replacing the Sherman-Grimsrud infiltration. Perhaps allow specification of a schedule for the ventilation.

Heat Recovery from Ventilation Air

The ACM does not address heat recovery.

DOE2.2 allows heat recovery from exhaust air in system types that provide ventilation (i.e. not RESYS).

Recommendation. Consider using the PSZ system type to allow specification of heat recovery.

Whole House Fan

The ACM does not give credit for whole house fans.

DOE2 does not include a whole house fan model. However, its cooling impact can be approximated using the natural ventilation algorithm and setting the ventilation rate to a high value. The energy consumed by the fan would have to be calculated separately, complicating the process because the run hours for the fan are not known.

Another option is the night ventilation algorithm in DOE2. This allows the fan to come on after hours to provide cooling with outdoor air. Using this method requires a system type like PSZ that permits outdoor air ventilation.

Recommendation. Consider PSZ and the night vent option. Otherwise, use natural ventilation together with typical values for whole house fan electricity consumption.

Duct Losses

Duct losses in residential buildings are a very significant issue. A great deal of research has been performed in this area in the past 10 years or so. DOE-2.2 has added capabilities for modeling ducts that consider the location of the ducts, e.g. in-the-house, attic, etc. The modeling options for ducts will be explored and a recommendation will be developed for the tool

The ACM (in its Appendix F) specifies an algorithm for Seasonal Distribution System Efficiency that is a function of duct location, duct insulation, house age, climate zone, number of stories, and floor area (and possibly other inputs). Measured leakage data may also be used.

DOE2.2 and DOE2.1Ev110 calculate duct losses based on inputs DUCT-AIR-LOSS (the fraction of air leaking from the duct) and DUCT-UA (the product of duct conductance and surface area). Losses are assigned to an unconditioned zone such as the attic or crawlspace.

Recommendation. Use the 2.2 method for duct modeling, and develop a method to estimate leakage fraction and surface area based on user inputs (such as those used in the ACM model).

Shading from Adjacent Building

Shading from trees and adjacent buildings might be a very significant factor. Residential buildings are typically modeled with no shading, which is clearly wrong. In residential suburbs, neighbor houses on the left and right provide significant shading. The front and back have more glass, which has less shading. All energy simulation models, including DOE-2 have the capability to model exterior shading.

The ACM does not allow consideration of shading from adjacent buildings or landscaping for compliance calculations.

Recommendation. Use the DOE2 fixed shade command, and allow the user to choose a seasonal transmittance schedule if the shade is a deciduous tree.

Interior Blinds and Drapes

The operation of interior blinds and drapes can have a significant impact on building energy use. There are two modeling issues. The first relates to how the drapes/blinds are operated. The second issue relates to the effectiveness of the blinds when they are closed.

The residential ACM specifies methods for modeling draperies and blinds. Credits are offered for standard draperies, venetian blinds and roller shades. The credit for roller shades will be eliminated in 2002. The credit is offered by two values of SHGC: one for when the shade is open and one for when it is closed. The residential ACM gives methods for combining the SHGC of windows with the SHGC of blinds (see ACM, page 4-7). The control algorithm assumes that the drapery is closed when the air conditioner is running and open at other times (see ACM, page 4-5).

With DOE-2.2, blinds can be explicitly modeled as a layer of the window, using advanced algorithms. Another option is to use DOE2's window covering model which applies a heat gain multiplier to solar gain through windows. The shade may be controlled based on a threshold for heat gain, and probabilities of operation may be applied.

Recommendation. Use the window covering algorithm rather than the newer method that includes the blind as one of the window layers because the latter method applies only to slat-type blinds (and not drapes or roller blinds) and does not offer possibility of probability schedules for operation.

Overhangs and Exterior Window Shades

In ACM allows for the impact of overhangs and sidefins to be calculated based on sun angle. Exterior shades, such as shade screens, are assumed to be in place all year if they are included in the compliance calculations.

Recommendation. Model exterior shades using the window covering algorithm as described for interior blinds. Model overhangs and sidefins using the building shade function in DOE2, which includes the shading impact on walls as well as windows (the alternative is to assign an overhang and/or sidefin to each window, but then the wall shading impact is not included). To include the shading impact of one wall on another wall, as might happen in an L-shape floorplan, model exterior walls as shading surfaces.

Modeling Windows

The ACM requires only a simple U-factor and SHGC input for windows. Title 24 includes a default table for these values, or NFRC rating values may be used.

Recommendation. Allow users to create window types using the window layer option in DOE2.2. That allows accurate modeling of a wide variety of glazings. If users have NFRC ratings for their windows, then they will be given the option of simply entering the U-factor and SHGC directly into DOE2's simple window algorithm.

Radiant Barriers

Energy credit for radiant barriers may be used with approved 1998 alternative calculation methods (ACMs). Approved ACMs must be able to model radiant barriers and calculate ceiling U-value modifiers that are functions of the ceiling insulation and the season as well as attic temperature reductions which result in better HVAC distribution efficiencies for ducts in the attic below a radiant barrier.

For installed insulation greater than R-8:

$$UvalMod_{heating} = (-11.404 \times U_2) + (0.21737 \times U) + 0.92661 \quad \text{Equation 4.41}$$

$$UvalMod_{cooling} = (-58.511 \times U_2) + (3.22249 \times U) + 0.64768 \quad \text{Equation 4.42}$$

Otherwise these modifiers are 1.000.

Recommendation. See the method described by Parker and employed in Energy Guage for modeling radiant barriers in attic constructions.

Reflective Roof Surfaces

In the ACM, all surfaces exposed to solar gain have an absorptivity of 0.5 (which is low for most roofing materials).

Recommendation. Allow the user to enter roof surface absorptivity and emissivity, and also give the option to choose from a list of different surface types to get default values. Check the paper by Parker [1998] for potential modifications to the DOE2 model to more accurately calculate the impact of reflective roof surfaces.

Modeling Attics and Ceilings

Recommendation. See the method described by Parker and employed in Energy Guage for attic constructions. Model framed roof constructions (those without attics) using the same method as for walls.

Modeling Walls

The ACM requires the parallel path method for U-factor calculations when framing members are present in a construction. For metal framing, one of several methods may be used including, the zonal calculation

method, modified zonal calculation method, finite element or finite difference methods, or the CEC's EZ-frame computer program

Recommendation. Include default wall constructions for the users to choose that will cover typical cases as well as less common constructions such as straw bale and rammed earth. Otherwise, allow users to create a custom construction.

T h e r m o s t a t S c h e d u l e s

The ACM thermostat schedules are listed above in Table 1.

Recommendation: The user will be able to either choose from a set of occupant profiles that include default schedules or may modify thermostat schedules for each controled zone.

Equipment Performance

H V A C S y s t e m s

DOE-2 has significant modeling capabilities for HVAC systems. This is a major improvement over models like MICROPAS and CALRES, that lack equipment models. The RESYS2 system is the most likely model to use for residential buildings. This model permits consideration of natural ventilation through windows or other techniques, and also allows the entrance of fan-controlled outside air.

The user will have the following system choices:

Cooling:

- Central air conditioning (RESYS2)
- Room air conditioner(s) (PTAC)
- No cooling

Heating:

- Gas Furnace
- Heat Pump (HP)
- Electric Resistance
- Hydronic

Equipment sizes. Default size will be taken from CEC or LBL databases. The user will also be able to enter sizes for heating and cooling in Btu/h

Efficiency. We will use the DOE-2 defaults for default equipment efficiency. Users will also be able to input EER for cooling equipment and % efficiency or COP for heating equipment. User will also be able to enter the year built instead of the efficiency. Average efficiency for equipment of that vintage will be used.

Part Load Efficiency. RESYS2 and other DOE-2 systems have sets of default part load equipment performance.[3] Recent research by Henderson (1998a) based on empirical assessment of current generation heating and cooling equipment has resulted in a new set of part load performance curves that are considered to be more accurate than the DOE-2.1E default curves for residential furnaces, air conditioners and heat pumps. These new curves have been implemented as the default curves for RESYS2 and other systems in DOE-2.2. In addition to "typical" performance, Henderson also developed curves for "good" and "poor" systems. We will consult with Henderson to develop layman's definitions of good, versus typical and poor. For example, "good" could represent any system built after 1997, and any system built before 1977 would be

W a t e r H e a t i n g S y s t e m s

Water heating energy is quite significant in California residences. Along the coast, air-conditioning is rare and space heating energy is moderate. Water heating energy along with electrical energy for lighting and appliances are the most significant components of energy use.

[3] HVAC and water heating equipment have several sets of performance curves. For instance air conditioners have curves that explain cooling capacity vs. wetbulb and drybulb temperature, cooling efficiency vs. part-load ratio, and cooling efficiency vs. wetbulb and drybulb temperatures. For multiple speed compressors, additional curves explain equipment performance as the compressor motor slows.

ACM Water Heating Model

The residential ACM has a water heating calculation method that must be used by tools used for low-rise residential compliance calculations. This method is documented in Section 4.20 of the 1998 manual. This method has evolved over the years as a result of requests by water heater product venders to include different measures and system options. The calculation procedure works with a variety of water heating features and systems including:

- A variety of distribution systems are supported (see Table 3). These work to increase or reduce the water heating recovery load. With a re-circulating system and no control, for instance, the recovery load is assumed to be increased by 52% (multiplier of 1.52). This procedure works as long as the method is returning an estimate of source energy (which is the case with the ACM). It does not separate the electric energy used by the pumps from the gas energy used by the water heater(s) and this is a problem for a program that needs to accurately estimate energy costs.

  Table 3 –Distribution System Multipliers (DSMs)

	Distribution System Multipliers	
Distribution System	Single Family	MultiFamily
Standard	1.00	1.00
POU	0.82	Na
HWR	0.82	Na
Pipe Insulation	0.92	0.92
Parallel Piping	0.86	0.86
Recirc / NoControl	1.52	1.52
Recirc / Timer	1.28	Na
Recirc / Temp	1.05	1.05
Recirc / Demand	0.98	Na
Recirc / Time + Temp	0.96	Na
Recirc / Demand + HWR	0.80	Na
Recirc / Demand + Pipe Insulation	0.90	Na

- The method can model multiple water heaters in the same system. The water heaters have to all be of the same size and type, however.
- A variety of water heater types can be modeled including those covered by the NAECA standards (storage gas, storage electric, and heat pump water heaters), and other types that are not covered by NAECA. These include instantaneous gas, large storage gas (larger than 75,000 Btu/h input), and indirect gas water heaters (boiler and separate storage tank). For NAECA water heaters, only the energy factor (EF) and the adjusted recovery load is needed in the calculations. Other inputs are needed for large storage water heaters.
- Credits can be taken for heat exchangers in wood stoves or solar systems (either active or passive). If credit is taken for solar, a separate calculation must be performed using f-Chart that determines the solar credit.
- The water heating recovery load is calculated as a function of the conditioned floor area of the house. The saturation of hot water using appliances is not a factor.

The ACM water heating method makes an estimate of annual source energy. It can easily be modified, however, to break down electric and gas energy, which would be needed by an accurate energy cost estimating tool. The equations that give recovery load as a function of conditioned floor area do not break down the load on an hourly basis, they only give the annual load.

EPRI/LBNL Water Heating Models

Research at LBNL and EPRI have produced water heating models that are also worthy of consideration. There are really two separate research efforts. The first is a model that predicts water heating use (or consumption). The second is a simple equation that estimates the energy used by the water heater.

Water Heating Use

The model for water heating use produces an hourly profile of water heating use in liters (or gallons) per hour. The model was originally developed through EPRI research[4], but later modified by researchers at LBNL to consider whether the house has dishwashers and/or clothes washers. Modifications were also added to consider the effect of seniors in the household and whether or not the occupants pay their energy bills for water heating. The following factors are considered in the model[5].

- Demographic information on the number of persons in the household, with a breakdown on the number of preschool children, school age children, and adults. If the occupants are all seniors, this is also a factor in the estimate.
- Water heater tank size and setpoint temperature.
- Whether or not adults are home during the day.
- The season of the year and the outdoor air temperature.
- Information on whether the house has dishwashers and/or clothes washers.
- Information on whether the occupants pay their own utility bill.

Once this data is entered, then the model will produce an estimate of hourly hot water consumption. The method produces eight 24-hour schedules: weekday and weekend consumption times four seasons in the year. The method has a lot of advantages over the ACM hot water loads method, in that it is sensitive to more factors (the ACM only considers house size), and it produces an hourly schedule.

Water Heating Energy

LBNL has produced a simplified equation for estimating water heating energy. The procedure is called the Water Heater Analysis Model or WHAM.[6] The method estimates daily water heating energy consumption as a function of the following factors.

- The recovery efficiency of the water heater. This data is available from the CEC directories
- The rated power input to the water heater in Btu/h.
- The stand-by loss coefficient in Btu/h-F.
- The thermostat setpoint of the water heater.
- The inlet water temperature
- The air temperature of the room where the water heater is located.
- The volume of water that is drawn over the 24 hour period, and properties of water such as the specific heat and density (constants).

WHAM has been validated against more detailed water heating simulation models and shown to be very accurate. The published version of the WHAM equation estimates daily water heating energy, but the equation could be easily modified to produce hourly estimates.

DOE-2.2 Water Heating Model

The DOE-2 water heating model was improved considerably when Version 2.1E was released. The water heating load is specified as a peak load in gallons/minute (DHW-FLOW), which is modified by a schedule

---

4 Hiller, C.C., A.I. Lowenstein, and R.L. Merriam, WATSIM User's Manual, Version 1.0: EPRI Detailed Water Heating Simulation Model Users Manual. TR-101702, Palo Alto, EPRI, 1992.

5 The model is documented in Lutz, et. al.

6 Lutz, Jim, C.D. Whitehead, A. Lekov, D. Winiarski, and G. Rosenquist, *WHAM: A Simplified Energy Consumption Equation for Water Heaters*, ACEEE 1998 Proceedings, Page 1.171.

(DHW-SCH). This consumption rate and schedule could be produced by the EPRI/LBLN model. Other factors that are taken into account are listed below:

- The inlet temperature (DHW-INLET-T-SCH). This can be specified as an hourly schedule, however, the default value is the monthly ground temperature from the weather tape.
- The supply temperature (DHW-SUPPLY-T). A single value is specified
- The energy input rating for the water heater in Btu/h (DHW-HEAT-RATE).
- The type of water heater (DHW-TYPE). There are several options: GAS, ELECTRIC, HEAT-PUMP, DESUPERHEAT, or WASTE-HEAT. The first three are modeling options with the ACM and LBNL methods. The last two depend on interactions with other systems, and are only available with DOE-2. The desuperheater option recovers heat from an electric heat pump. The waste heat option recovers energy from a gas heat pump. For desuperheaters, the system type must be a ResVVT.
- The efficiency of the water heater (DHW-EIR). The efficiency is specified as an energy input ratio, which is the reciprocal of the efficiency. The value is specified for peak conditions and is modified by the part-load curves for other conditions. This value is not generally available. It is not required to be reported by NAECA nor is it listed in the CEC appliance directories.
- Part load curves for the water heater. Three part load curves are specified: DHW-EIR-FT (modifies the equipment efficiency as a function of outdoor drybulb temperature), DHW-HEAT-RATE-FT (modifies the heat input rate as a function of outdoor drybulb temperature), and DHW-EIR-FPLR (modifies the energy input ratio of the equipment as a function of the part load ratio). For water heaters located indoors or in unconditioned spaces, the first two functions are only important for heat pump water heaters. The third term, however could be quite significant. The following figure shows the default DHW-EIR-FPLR performance curve for gas water heaters. At part loads, the EIR of the water heater is reduced, which means that the water heater is more efficient.

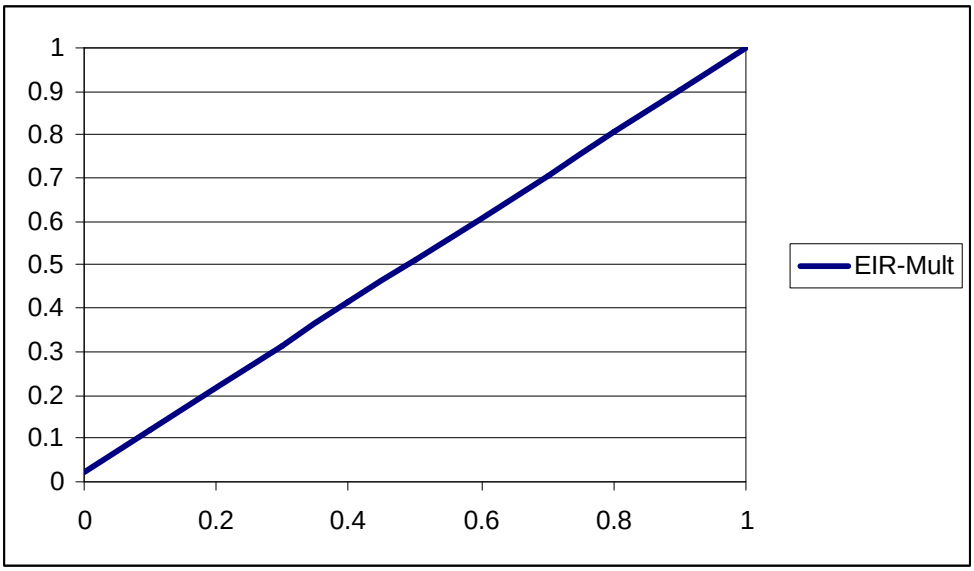


Figure 3 – Part Load Curve for Gas Water Heater

- The electric power used by a circulation pump (DHW-PUMP-ELEC). This is specified in watts/(Btu/h) of the water heater input rate (DHW-HEAT-RATE). If there is no circulation pump, this keyword should be set to zero.
- The schedule for operation of the circulation pump (DHW-PUMP-SCH). This is an hourly schedule. No options are provided for different ways of controlling the circulation pump, like with the ACM method. It

might be possible to produce some default operation schedules that match the credits/penalties published in the residential ACM.

- The maximum rate hot water supply rate (DHW-HSUP-RATE). This is specified in Btu/h. If this is specified, a ceiling is placed on the maximum hourly draw.
- The maximum rate for the supply of recovered energy (DHW-HSTOR-RATE). This is specified in Btu/h. This affects the performance of desuperheaters or heat recovery from gas heat pumps.

Water heating systems are a modeling weakness of DOE-2.2. The Title 24 procedures have a separate (non-simulation) method that has a number of advantages. This method, which is documented in the Residential ACM Manual, considers configurations, stand-by losses, distribution losses and other factors that are not considered in DOE-2. The Title 24 model is relatively simple and will be considered as an option or alternative to an hourly simulation of water heating energy. Davis Energy Group has an hourly model for water heating that has been used to for evaluation of ACMs (Alternative Calculation Methods). This task will explore the options and a recommendation will be developed for modeling water heatng systems.

Recommendations

The EPRI/LBNL consumption model should be implemented as this would enable consideration of factors that are known to affect hot water use. The ACM consumption model should be implemented as an alternative. For the energy use calculations, all three methods have advantages and all should be implemented, allowing the user to pick the model he/she wants to use. The DOE-2.2 model is needed in order to model desuperheaters or heat recovery from gas heat pumps. The ACM method considers distribution types, can model multiple water heaters, solar contributions and other factors. WHAM has been validated as being accurate against more detailed models.

L i g h t i n g

Annual Energy. Several sources including HMG (1996) and Wenzel (1997) have compiled lighting survey data from a number of sources. Default whole house lighting will be taken from one of these sources and will be based on house type and possibly house area. For example:

	Kwh/yr (HMG)	Kwh/yr (Wenzel)
Single family	2076	1600
Multi-family	1084	799
Mobile home		849
Total population	1704	1274

Users will also have the option of specifying either the number of fixtures in each room or the approximate wattages and hours of operation of all fixtures. If they specify the number of fixtures we will use the survey data to assume wattages and hours of operation per fixture. If they specify the wattages and hours, then the annual consumption is simply the sum of watts x hours.

Lighting Schedules. We will use the ACM Hourly Schedule of Internal Gains (see Figure 1) to distribute total lighting consumption on an hourly basis. We will use the "whole" building schedule unless the user specifies fixtures by room, in which case we will use the "sleeping" schedule for bedrooms and the "living" schedule for all other rooms.

H o u s e h o l d A p p l i a n c e s

Annual Energy. Data from Wenzel (1997) and other sources will be used to develop simple equations for appliance energy. We expect that more significant appliance equations will have more independent variables (for which there will be default values as well as optional user input) while less significant appliances will be a constant amount if the appliance is present. The following is a preliminary list of appliances and independent variables

Table 4 – Energy Model for Household Appliances

Appliance	Function of …
refrigerator	# refrigerators year made size (small, medium, large, ex-large) freezer location (side-by-side, top freezer) defrost (automatic, manual) through-the-door ice service (yes, no)
Stand-alone freezer	# freezers year made size (small, medium, large, ex-large) type (upright, chest) defrost (automatic, manual)
stove	Fuel (electric, gas/propane) Total burner hours/day Pilot light (yes, no)
oven	Fuel (electric, gas/propane) Total hours/week Pilot light (yes, no)
dishwasher	Loads/week
Clothes washer	Loads/week at each wash/rinse temperature (hot/warm, hot/cold, warm/warm, warm/cold, cold/cold)
Clothes dryer	Fuel (electric, gas/propane) Total loads/week
Bottled water cooler	Used regularly?
Coffee machine-drip	Used regularly?
Coffee machine—percolator	Used regularly?
Deep fryer	Used regularly?
Electric fry pan	Used regularly?
Espresso machine	Used regularly?
Microwave oven	Used regularly?
Toaster	Used regularly?
Toaster oven	Used regularly?
Trash compactor	Used regularly?
Broiler	Used regularly?
Slow cooker	Used regularly?
Instant hot water tap	Used regularly?
Upright vacuum cleaner	Used regularly?
Canister vacuum cleaner	Used regularly?
Dustbuster	Used regularly?
Answering machine	Used regularly?
Stereo system	Size (large, small), usage (>3 hrs/day, <3 hrs/day)
Cable box	Used regularly?
Color TV	Hrs/day for all TVs combined
Computer	Used regularly?
printer	Type (inkjet, dot-matrix, laser)
copier	Hrs/day left on
Fax machine (not in computer)	Used regularly?
Satellite dish	Used regularly?
VCR	Used regularly?
Video game	Used regularly?
Swimming pool pump	Hrs/day that pump runs, months/year of pool use
Pool heater	Fuel
Spa, hot tub	Fuel, hrs/week heater on

Sump/sewage pump	Used regularly?
Well pump	Used regularly?
Aquariums	Used regularly?
Electric blanket	Used regularly?
Electric grill	Used regularly?
Garage door opener	Used regularly?
Hair dryer	Used regularly?
Heat tape	Used regularly?
Iron	Used regularly?
Pipe and gutter heaters	Used regularly?
Automobile block heater	Used regularly?
Waterbed heater	Used regularly?
Dehumidifier	Used regularly?
Humidifier	Used regularly?
Electronic air cleaner	Used regularly?
Gas fireplace	Used regularly?
Gas grill	Used regularly?
Gas fireplace with ceramic logs	Used regularly?
Gas lighting	Used regularly?

Hourly Schedules. We will use the ACM Hourly Schedule of Internal Gains (see Figure 1) to distribute total appliance consumption on an hourly basis. We will use the "whole" building schedule for most appliances. We will add at least one more schedule: a flat line for relatively constant loads like refrigerators and freezers.

Operating Conditions

This is Task 2.2.3 which will be completed August 15.

Measured or Calibrated Data

This is Task 2.2.4 which will be completed August 15.

REFERENCES

Bazjanac, Vladimir*, The Modeling of Two-Dimensional Heat Flow in DOE-2 Simulation*, CEC, December 1996.

BESG, 1981. DOE-2 Engineer's Manual, Version 2.1A, Building Energy Simulation Group, Lawrence Berkeley National Laboratory, LBL-1153, Berkeley, CA.

California Energy Commission, *DRAFT 15-DAY LANGUAGE (Revised from EXPRESS TERMS) LOW-RISE RESIDENTIAL ALTERNATIVE CALCULATION METHOD APPROVAL MANUAL For the 1998 Energy efficiency Standards for Low-Rise Residential Buildings*, July 24, 1998.

California Energy Commission, *Residential Manual*...

Christian, Jeffery E, *Thermal Performance and Wall Rating*, website http://www.ornl.gov/roofs+walls/articles/WallRating.html.

Eley Associates, *Algorithms and Assumptions*, 1989?

Gartland, Lisa, *Modeling the Effects of Reflective Roofing*, ACEEE Proceedings, 1996, p 4.117.

H. I. Henderson, K. Rengarajan and D. B. Shirey, 1992. "The Impact of Comfort Control on Air Conditioner Energy Use in Humid Climates," ASHRAE Transactions, Vol. 98, Pt. II, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

Henderson, Hugh, *Residential Equipment Part Load Curves for Use in DOE-2*, LBNL, February, 1999.

H. I. Henderson, 1998a, Part Load Curves for Use in the DOE-2 Simulation, CDH Energy Corp., Cazenovia, NY, January, 1998.

H. I. Henderson, 1998b. Integrating the DOE AC SYS Routine into RESYS in DOE-2, CDH Energy Corp, Cazenovia, NY, March, 1998.

Huang, Joe, *Two-Dimensional Wall Response Factors*, Simulation User News, Fall 1996.

Huang, Joe, *Various DOE-2 Functions, Memorandum,* September 8, 1994.

Konopacki, Steven, *Trade-Off Between Cool Roofs and Attic Insulation in New Single-Family Residential Buildings*, ACEEE Proceedings, 1998, p. 1.159.

Heschong Mahone Group (HMG), 1996. Residential Lighting Baseline: Lighting Efficiency Technology Report, California Energy Commission Contract #400-95-012, September, 1996.

W. Marion and K. Urban, 1995. User's Manual for TMY2s: Typical Meteorological Years, NREL/SP-463-7668, National Renewable Energy Laboratory, Golden, CO.

R. Meldem and F. Winkelmann, 1995. Comparison of DOE-2 with Measurements in the PalaTest Houses, LBL-37979, Lawence Berkeley National Laboratory, July, 1995.

ORNL, *Modified Zone Method Calculator*, website, http://www.ornl.gov/roofs+walls/mod_zone/index.html.

ORNL, *Highly-Reflective Low-Slope Roofs*, website http://www.ornl.gov/roofs+walls/roof/coatings.html.

Parker, Danny, *EnergyGuage USA: A Residential Building Energy Simulation Design Tool.*

D.S. Parker, P. Fairey and L. Gu, 1993. "Simulation of the Effect of Duct Leakage and Heat Transfer on Residential Space Cooling Use," Energy and Buildings, 20, Elsevier Sequoia, Netherlands.

D.S. Parker, J.R. Sherwin, R.A. Raustad and D.B. Shirey, 1997. "Impact of Evaporator Coil Air Flow in Residential Air Conditioning Systems," ASHRAE Transactions, June 28, 1997, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

D.S. Parker, Y.J. Huang, S. J. Konopacki, J. R.Sherwin and L. Gu, 1998. "Measured and Simulated Performance of Reflective Roofing Systems in Residential Buildings," ASHRAE Transactions, 1998 Winter Meeting, San Francisco, CA, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

S. Reilly and W. Hawthorne, 1998. "The Impact of Windows on Residential Energy Use," ASHRAE Transactions, Vol. 104, Pt. 2, 1998 Winter Meeting, San Francisco, CA, American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, GA.

Ternes, Mark, *Modeled and Metered Energy Savings from Exterior Wall Insulation*, ACEEE Proceedings, 1996, p. 1.171.

T. Wenzel, J. Koomey, et al., 1997. Energy Data Sourcebook for the US Residential Sector, LBL-40297, Lawence Berkeley National Laboratory, September, 1997.

F. C. Winkelmann, B. E. Birdsall, W. F. Buhl and K. L. Ellington, A.E. Erdem, J.J. Hirsch and S. Gates, 1993. DOE-2 Supplement, Version 2.1 E, LBL-34947, Lawrence Berkeley Laboratory, Berkeley, CA.

F. C. Winkelmann, 1998. "Underground Surfaces: How to Get a Better Underground Surface Heat Transfer Calculation in DOE-2.1E," Building Energy Simulation, Vol. 19, No. 1, Spring, 1998, Simulation Research Group, LBNL, Berkeley, CA.

Appendix IV
Validation Report

HomeEnergy Software

Task 2.8.2
Final Validation Report

December 26, 2000

Prepared for:
California Energy Commission
John Eash, Contract Manager

Contract Number 500-98-025

142 Minna Street
San Francisco, California 94105
(415) 957 1977 Voice
(415) 957 1381 Fax
www.eley.com

Contents

Contents....1
Introduction....1
Purposes of Validation....1
Source Data....1
Validation Procedure....3
Analysis of Results....4
Conclusion....7
Appendix....7

Introduction

HomeEnergy is a comprehensive analysis tool of residential energy use being developed by Eley Associates through PIER II funding. *HomeEnergy* has matured from several phases including, mockup, alpha version testing, and beta version testing. The software has been significantly improved based on feedback from CEC staff, focus groups, and outside testers.

This document is the final validation report for HomeEnergy software. The purpose of validation is to make sure HomeEnergy runs smoothly and produces correct simulation results. There are three approaches to validate an energy simulation program,

1. *Analytical Solution.* This approach assumes an ideal house model with a single room, simple constructions, and theoretical harmonic weather conditions like temperature, humidity and solar radiation, and by comparing the simulation results with the analytical solutions of indoor air temperature and thermal loads to validate the program.
2. *Inter-model Comparison.* This approach compares simulation results from several programs based on the same house model, indoor heat gains and weather conditions to validate the program.
3. *Empirical Comparison.* This approach compares the simulation results with utility bills of houses using the actual house model and weather data.

As HomeEnergy is built on DOE-2 simulation engine, which has already been extensively validated, this report will take the approach of empirical comparison.

Purposes of Validation

Building energy simulation software and design tools are more and more employed in the energy efficient design and retrofit of buildings and HVAC systems. The purpose of validation is to make sure that the software runs simulations smoothly and produces correct calculation results. As DOE-2.1E version 110 from LBNL is the simulation engine for HomeEnergy, and DOE-2.1E has been well validated, it follows that *HomeEnergy* should produce correct calculation results if it generates correct DOE-2 input files. Therefore, the validation of *HomeEnergy* will focus on comparing simulation results with utility bills. However, the validation will also focus on the following:

1. Make sure that the HomeEnergy program runs fine, i.e., to fully debug the program and fix all known and found bugs.
2. Make sure that user interface of HomeEnergy works fine, i.e., what user inputs are reasonable and persistent.
3. Make sure that HomeEnergy produces correct DOE-2 input files based on user inputs and default values.

A revised version of HomeEnergy will be compiled after bug fixes and corrections made during the validation process, resulting in the final release version of HomeEnergy software.

Source Data

In order to compare simulation results with utility bills of houses on the same basis, the user has to input the actual house data to HomeEnergy including,

1. Size, constructions, orientation, shading, etc.
2. Lights and appliances
3. Occupants and behavior

4. Heating and/or cooling system, and hot water system
5. Hourly weather data required by DOE-2
6. Monthly and annual use of electricity and gas
7. End use breakdowns of electricity and gas use

The source data we use in this final validation report are two houses located in different California climate zones. These houses are from a residential database produced by PG&E for evaluation of their California Comfort Home Program. Data items 1 through 4 (see above) are provided from surveyor reports. PG&E utility data is available for item 6, and monthly heating and cooling degree-days are also available from the weather bureau to compare against weather data used in simulations.

The following tables contain details about the two houses, electricity and gas consumption, and a comparison of weather data.

Table 1 – Summary of Two Houses Used in Validation

Site No.	Climate Zone	Annual kWh	Annual Therm	Floor Area (cond.)	Nmbr. Floors	Azimuth	Nmbr. Occupants
6563447	11	14169	491	2929	2	120	4
6557413	12	7159	481	2223	2	90	4

Table 2 – Monthly Electricity Use (kWh) for Validation Houses

Site No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6563447	951	863	580	1390	1103	1590	1584	1576	1538	881	956	1156
6557413	479	426	452	310	486	610	1353	889	870	455	393	436

Table 3 – Monthly Gas Use (therms) for Validation Houses

Site No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6563447	86	46	46	33	18	19	16	17	14	22	55	119
6557413	121	81	61	31	19	8	6	6	6	15	38	88

Table 4 – Comparison on Heating Degree Days (base 65)

Site	HDD65	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
6563447	Actual	572	410	403	210	50	22	0	0	0	92	344	662	2765
	Simulation	602	399	349	198	40	9	0	0	24	86	378	574	2656
6557413	Actual	630	462	411	300	163	80	7	13	2	88	267	457	2880
	Simulation	597	397	339	210	58	13	3	8	7	86	356	578	2652

Table 5 – Comparison on Cooling Degree Days (base 65)

Site	CDD65	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
6563447	Actual	0	0	0	37	52	231	276	293	274	21	0	0	1185
	Simulation	0	0	0	2	109	272	395	352	219	38	0	0	1387
6557413	Actual	0	0	0	14	8	35	243	79	194	4	2	0	579

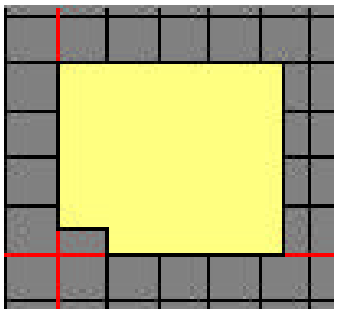
Simulation	0	0	0	5	64	185	294	283	173	35	0	0	1039

The appendix has detailed survey data and DOE-2 input files generated by HomeEnergy for the two houses used in the validation.

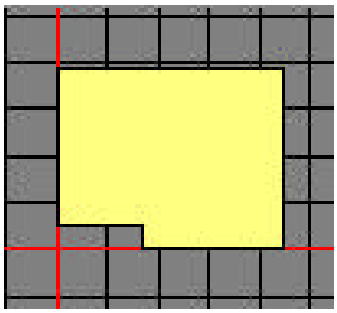
Validation Procedure

Validation of HomeEnergy includes four procedures as follows,

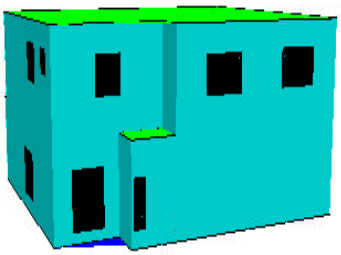
1. *Processing of source data.* As homeowners or surveyors provide most survey data, some data are incomplete, inaccurate, or missing. These data must be studied, corrected, and compiled to inputs for HomeEnergy.
2. *Create simulation models.* Use HomeEnergy to create two house models based on the compiled survey data and default values for residential houses from California Title 24 Residential Manual or ASHRAE publications. HomeEnergy accounts for garage in a house model as unconditioned area.



First Floor Plan View

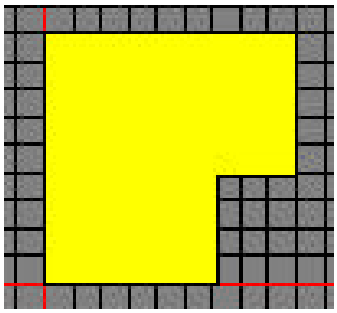


Second Floor Plan View

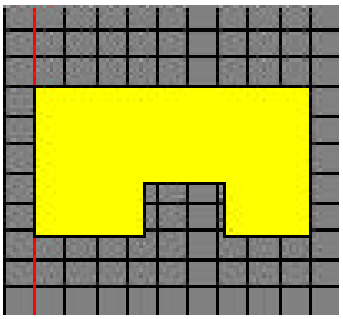


Three Dimensional View

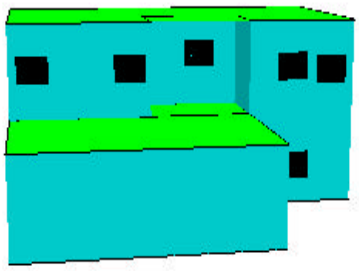
Figure 1 – House 6563447



First Floor Plan View



Second Floor Plan View



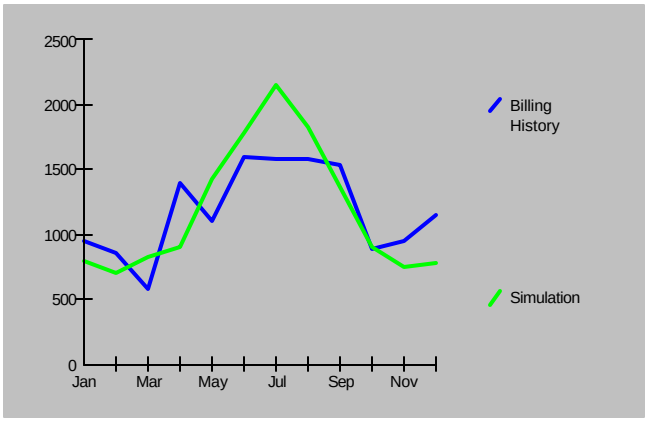
Three Dimensional View

Figure 2 – House 6557413

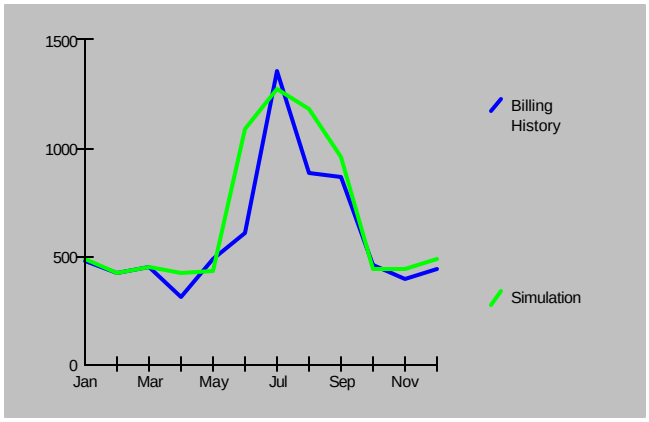
3. *Run simulations.* Run *HomeEnergy* to produce DOE-2 input files, and run DOE-2 to perform annual hourly energy simulations and produce monthly and annual electricity and gas use.
4. *Compare results.* Compare simulation results with utility bills on the basis of monthly and annual electricity and gas use.
5. *Adjust inputs.* Some adjustments of lights and appliances are made based on assumptions that during off cooling seasons the electricity use is only from lights and appliances, and during off heating seasons the gas use is only from appliances and hot water heating.

Analysis of Results

The following figures compare the results from *HomeEnergy* to the utility bills for the validation houses.

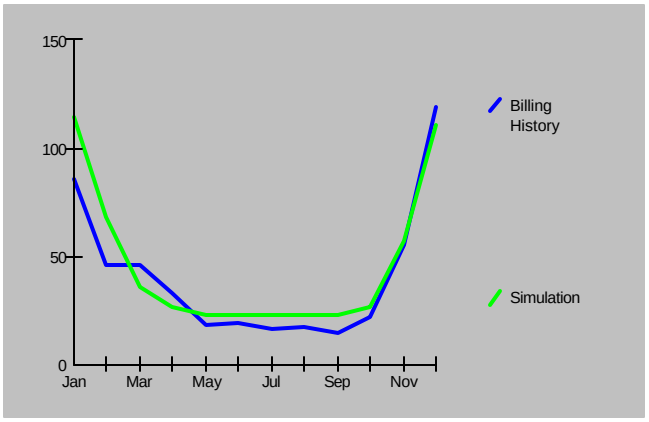


House 6563447

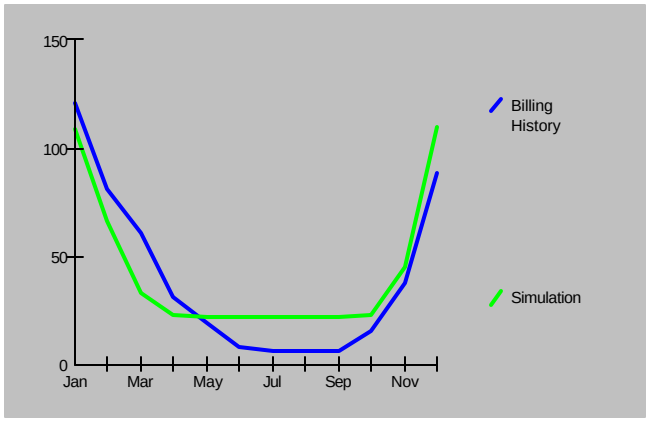


House 6557413

Figure 3 – Comparison of Monthly Electricity Use (kWh)



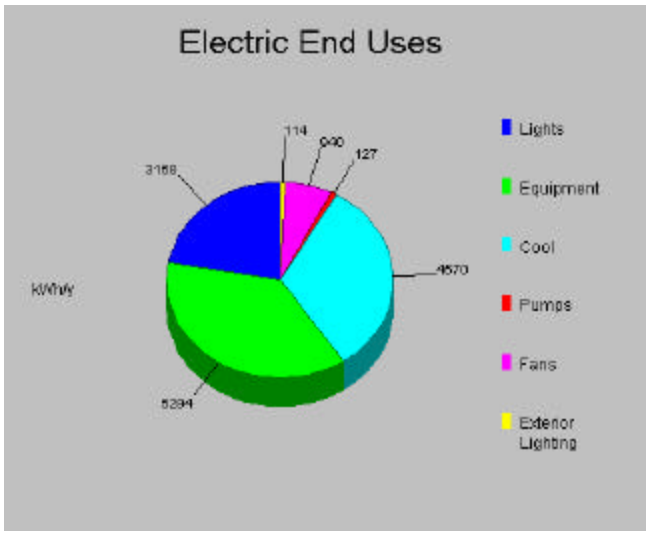
House 6563447

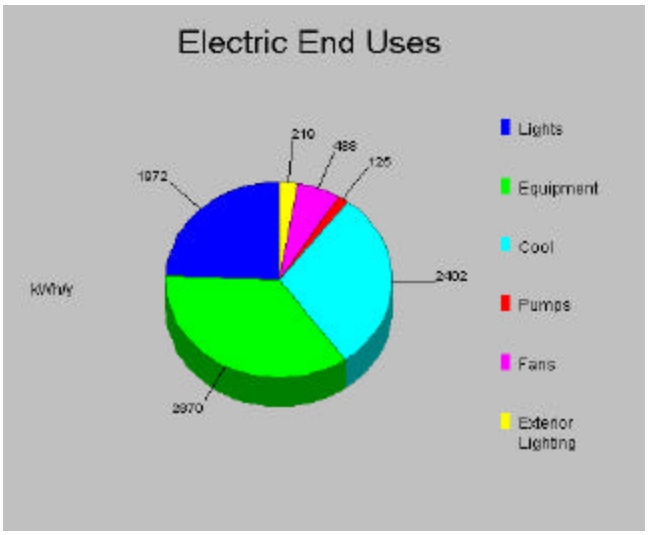


House 6557413

Figure 4 – Comparison of Monthly Fuel Use (Therms)

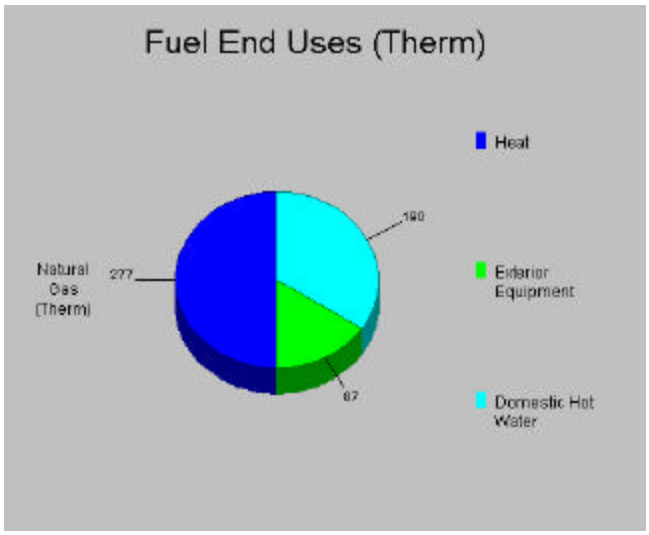
The following figures show the end-uses from the simulation. These cannot be compared to the billing history, since it is not possible to break down the billing data in this much detail.

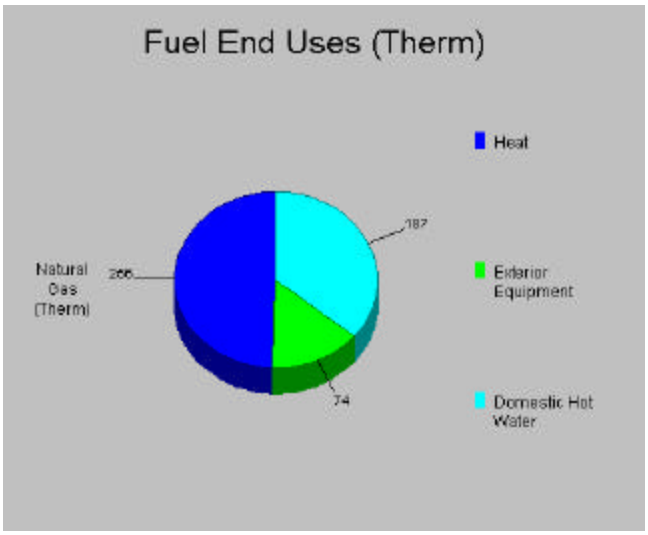




House 6563447 House 6557413

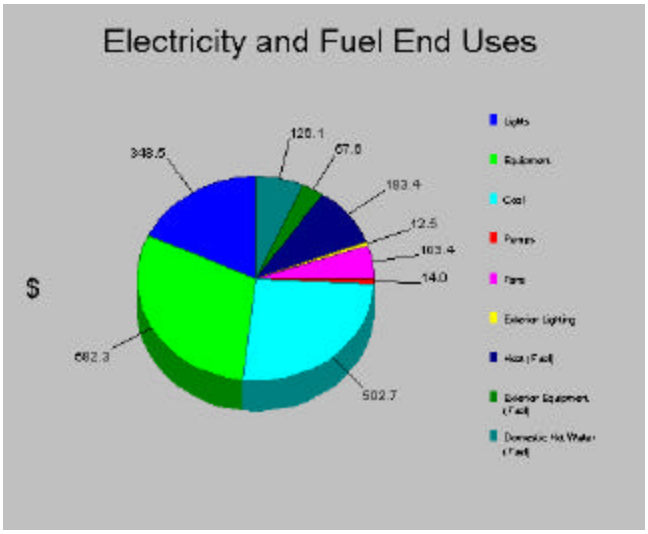
Figure 5 –Electricity End Uses (kWh) – Simulation

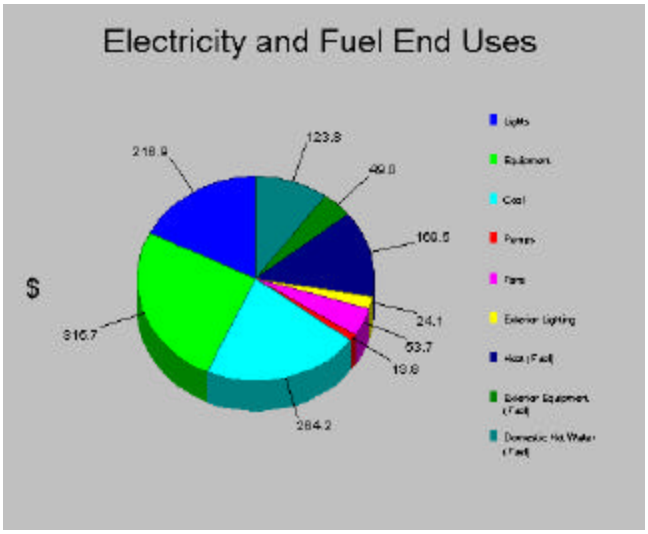




House 6563447 House 6557413

Figure 6 – Fuel End Uses (Therms) – Simulation





House 6563447 House 6557413

Figure 7 – All End Uses ($) – Simulation

Table 6 – Annual Results Summary

	House 6563447			House 6557413		
	Simulation	Bills	Error	Simulation	Bills	Error
kWh	14213	14169	0.3%	8076	7159	12.8%
Therms	554	491	12.8%	517	481	7.5%

From these figures and tables, we can see that *HomeEnergy* software produces reasonable calculation results of monthly and annual electricity and gas use. The differences between the simulation results and utility bills may be explained in the following ways:

1. *Different weather data.* DOE-2 simulation requires detailed hourly data of outside air dry-bulb and wet-bulb temperature, solar radiation, wind speed and direction, etc., but these data are not available from the survey data. Instead, California climate zone weather data are used in simulations. From Table of Actual Weather Data vs Simulation Weather Data, we can see that differences of heating and cooling degree days between simulation weather data and actual weather data may be significant for some months, thus the simulated monthly heating or cooling energy use for these months may be quite different.
2. *Lack of details of lights and appliances.* For residential houses, energy use of lights and appliances can be a big portion of total energy use, but the survey data doesn't document their exact energy use. For example, number of lights is documented but not watt and usage data.
3. *Family vacation not specified.* The utility bills sometimes show a significant drop of energy use independent of seasons, this may be because the family is on vacation. As the vacation is not documented in the survey data, *HomeEnergy* doesn't take this into account.
4. *Other assumptions and simplifications of house models in HomeEnergy.* Some simplifications of house shape (attic, slope roofs) are made in *HomeEnergy* modeling. Air duct modeling is simplified as a correction factor on heating and cooling system efficiency because the simulation engine DOE-2.1E v110 is not capable of modeling air ducts.

5. *Occupants behavior.* Occupants may change thermostat settings during cooling or heating seasons, and may open windows while the heating or cooling is on, these uncertainties can't be modeled with *HomeEnergy* software.
6. *Accuracy of DOE-2 simulation engine.* The DOE-2 simulation engine also contributes some trivial errors.

Conclusion

Having used *HomeEnergy* to create two real house models, some twenty bugs have been found and fixed, and some features have been improved. *HomeEnergy* is now more reliable and capable of producing correct DOE-2 input files and accurate simulation results. It is recommended that *HomeEnergy* be further validated when detailed house model and measured data are available.

Appendix

Survey data of the two houses.

House 6557413

BRENTWOOD, CA 94513

Dwelling Characteristics

Dwelling Type	1
Age of Home, years	2
Number of Levels	2
Estimated Conditioned Area, SF	2210
Estimated Unconditioned Area, SF	590
Weather-stripping around doors? (Y/N)	Y
Number of Bedrooms	5
Total Number of Rooms (excluding hallways, bathrooms, basement, closets, and any rooms not used as living space)	8

Dwelling Type Codes
1. Single-Family Stand Alone
2. Single-Family Attached
3. Multi-Family
4. Mobile Home
5. Other_____

Walls

Wall Reference Number	B1	B2	B3	B4
Wall Construction Code	2	2		
Wall Siding Type Code	3	3		
Percent Wall Below Grade	0	0		
Wall Thickness, inches	6	6		
Wall Insulation R-value	13	0		
Wall Percent Insulated	100	0		
Wall Color Code (1-dark, 2-medium, 3-light)	3	3		

Wall Construction Type Codes	*Wall Siding Type Codes*
1. No Exterior	0. None
2. 2"X4" Wood Frame	1. Wood Siding
3. 2"X4" Wood Frame w/ insul. sheet	2. Masonry Siding
4. 2"X6" Wood Frame	3. Stucco / Plaster
5. 2"X4" Metal Frame	4. Combination Wood + Masonry / Stucco
6. 2"X6" Metal Frame	5. Metal Siding
7. Concrete block	6. Vinyl Siding
8. Brick wall	7. Other
9. Other _____	

Windows

Window Reference	G1	G2	G3	G4
Window Type Code	1	2	2	4
Number of Panes	2	2	2	2
Frame Type Code	3	3	3	2
Glazing Type Code	1	1	1	1
Interior Shading Code	2	0	2	2
Exterior Shading Code	0	0	0	0

Window Reference	G5	G6	G7	G8
Window Type Code				
Number of Panes				
Frame Type Code				
Glazing Type Code				
Interior Shading Code				
Exterior Shading Code				

Window Type Codes	*Frame Type Codes*	*Glazing Type Codes*	*Interior Shading Codes*	*Exterior Shading Codes*
1. Window (opens) 2. Window (fixed) 3. Skylight 4. Door	1. Wood 2. Metal 3. Vinyl	1. Clear Glass 2. Tinted Glass 3. Reflective Film 4. Clear w/ Low-E 5. Tinted w/ Low-E 6. Opaque	0. None 1. Drapes 2. Blinds	0. None 1. Building 2. Trees/Foliage 3. Fence 4. Sunscreen or Awning

Ceilings*

Ceiling Reference	C1	C2	C3
Estimated Ceiling Area, SF	1170		
Description (1-attic above, 2-vaulted, 3-flat no attic)	1		
Insulation			
Insulation Type Code	2		
Insulation R-value	30		
Insulation Thickness, inches	10		
Percent Insulated, %	100		
Describe Insulation Condition (1-good, 2-fair, 3-poor)	1		
Skylights? (Y/N)	N		
Estimated Skylight Area, SF			
Window Reference (G1, G2, etc.)			

*Note: Identify the ceiling types on the floor plan (page 7) with a proper code (e.g. C1, C2).

Roof

Roof Exterior Color (Dark/Med/Light)	M
Roof Slope (1-almost flat, 2-average incline, 3-very steep)	2

Roof Insulation Type Codes

0. None
1. Fiberglass (batt)
2. Blown-in Cellulose
3. Rigid Board (isocyanurate/polystyrene)
4. Other _____

Floors*

Floor Reference	F1	F2	F3
Estimated Floor Area, SF	1170		
Floor Type Code	2		
Insulation R-Value	0		
Percent of the Floor Tiled or Vinyl	20		
Percent of the Floor Carpeted	80		

Raised Floor Only

Crawl Space Height (ft.)			
Crawl Space Wall Construction Type			
Is Crawl Space Vented? (Y/N)			
Crawl Space Wall Insulation R-Value			

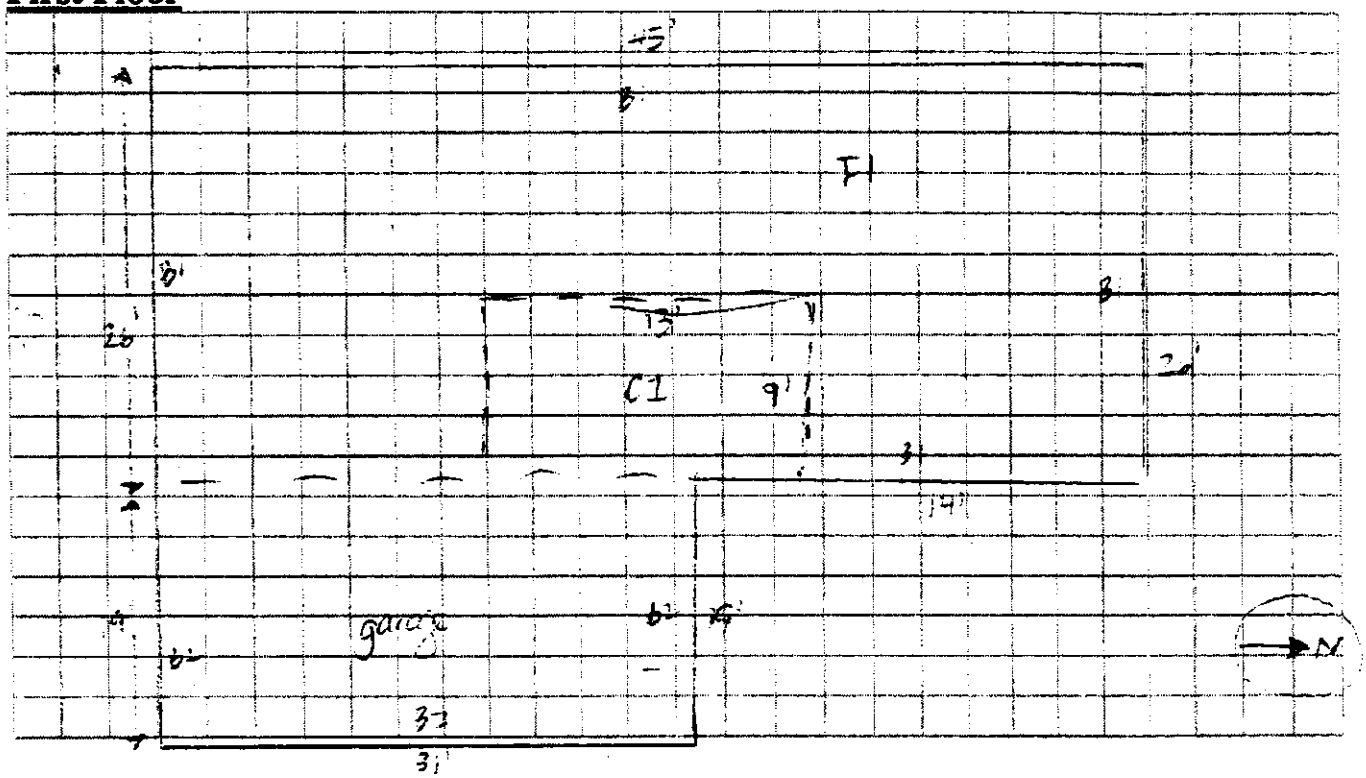
*Note: Draw the floor outlines on the floor plan (next page) and identify with a proper code (e.g. F1, F2..).

Floor Type Codes	*Crawl Space Wall Construction Type Codes*
1. Raised floor	1. Framed
2. Slab-on-grade	2. Concrete
3. Floor over Garage (or other unconditioned space)	3. Other: _____

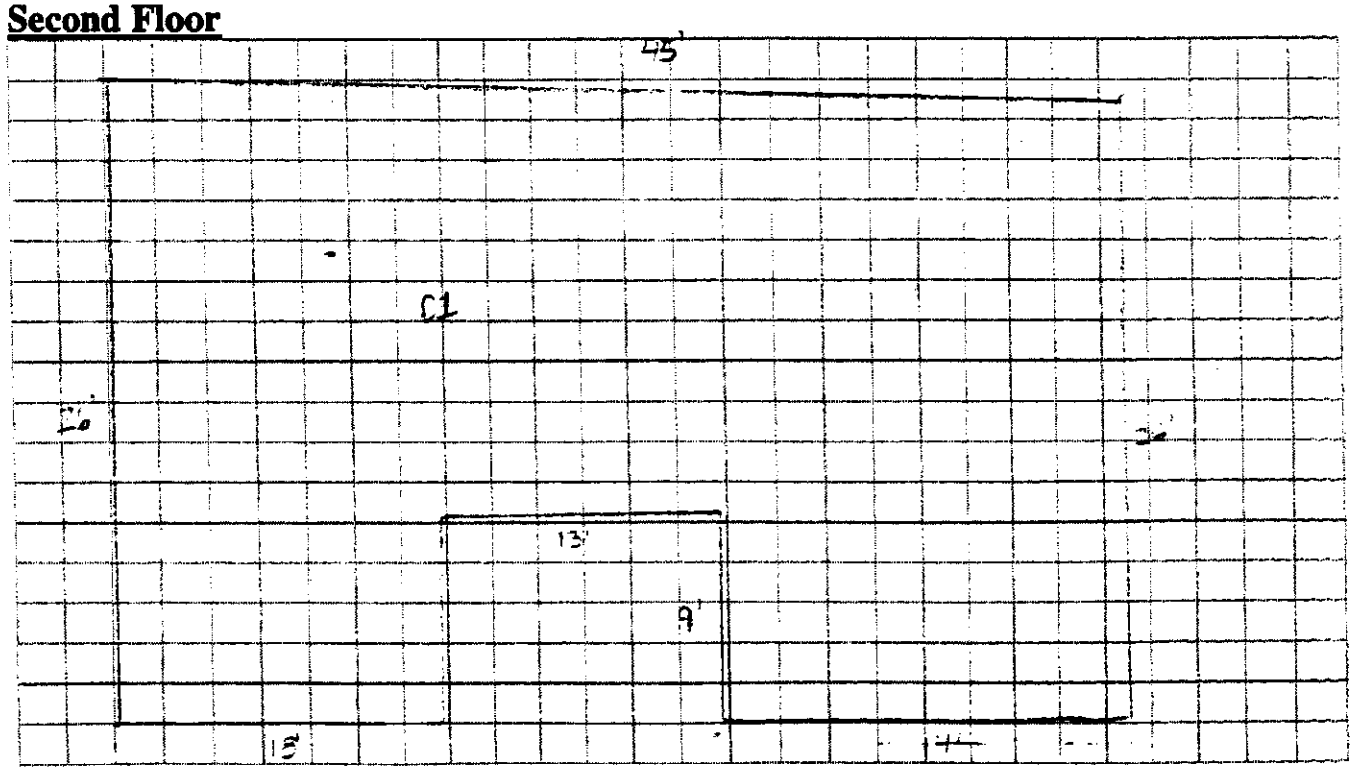
Floor Plan Sketches

① Include a Wall Reference Number for each wall (e.g., B1). The Reference Number will be the same for walls with the same construction characteristics. ② Record the outer length of each wall. ③ Indicate North with an arrow. ④ Identify all ceilings with the proper code (e.g., C1) and mark cathedral ceilings with cross-hatching. ⑤ Identify floors over unconditioned spaces (i.e., ground floor, and rooms over the garage). ⑥ Mark the location of the garage.

First Floor



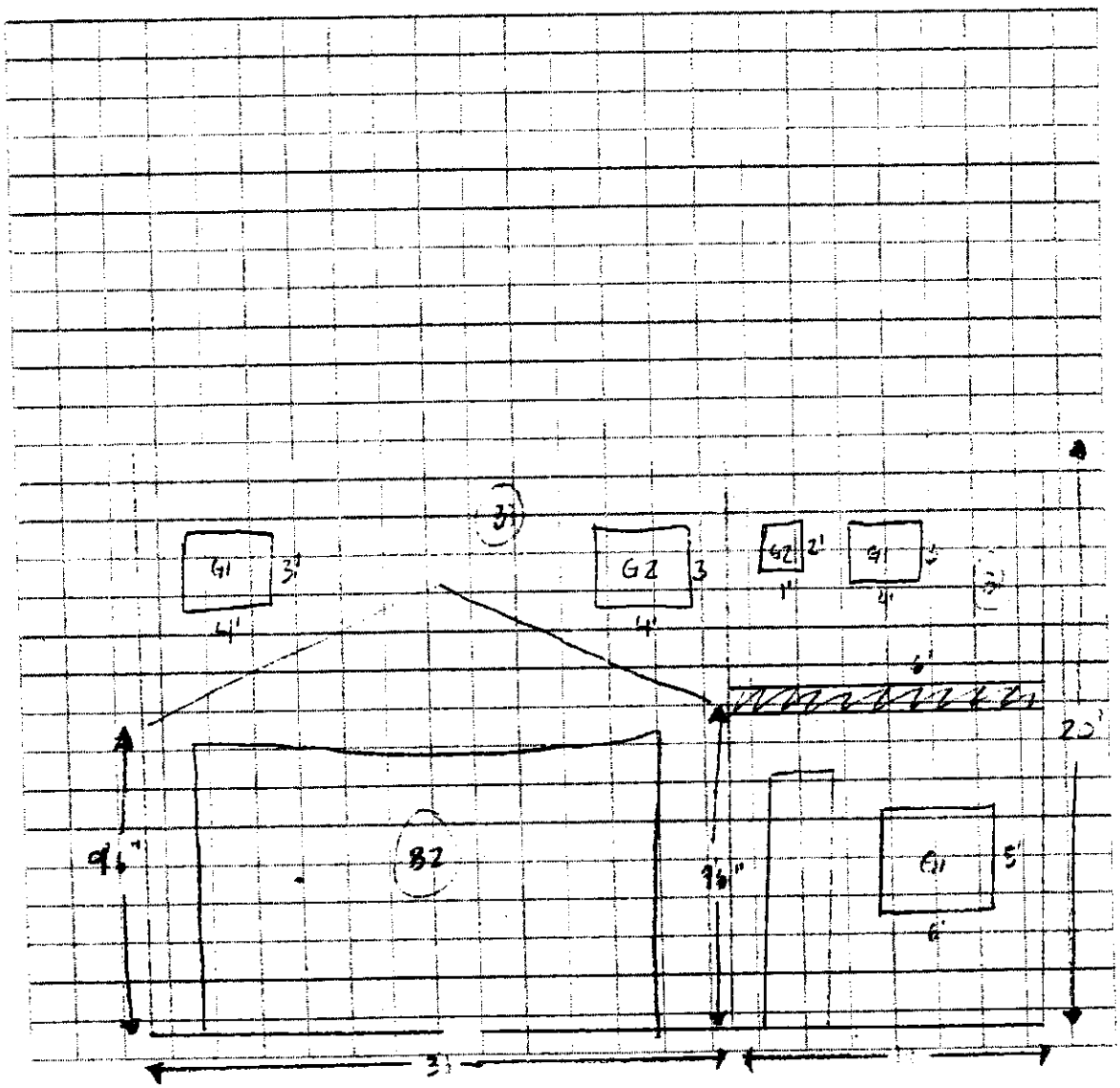
Second Floor



Elevation Sketch #1

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

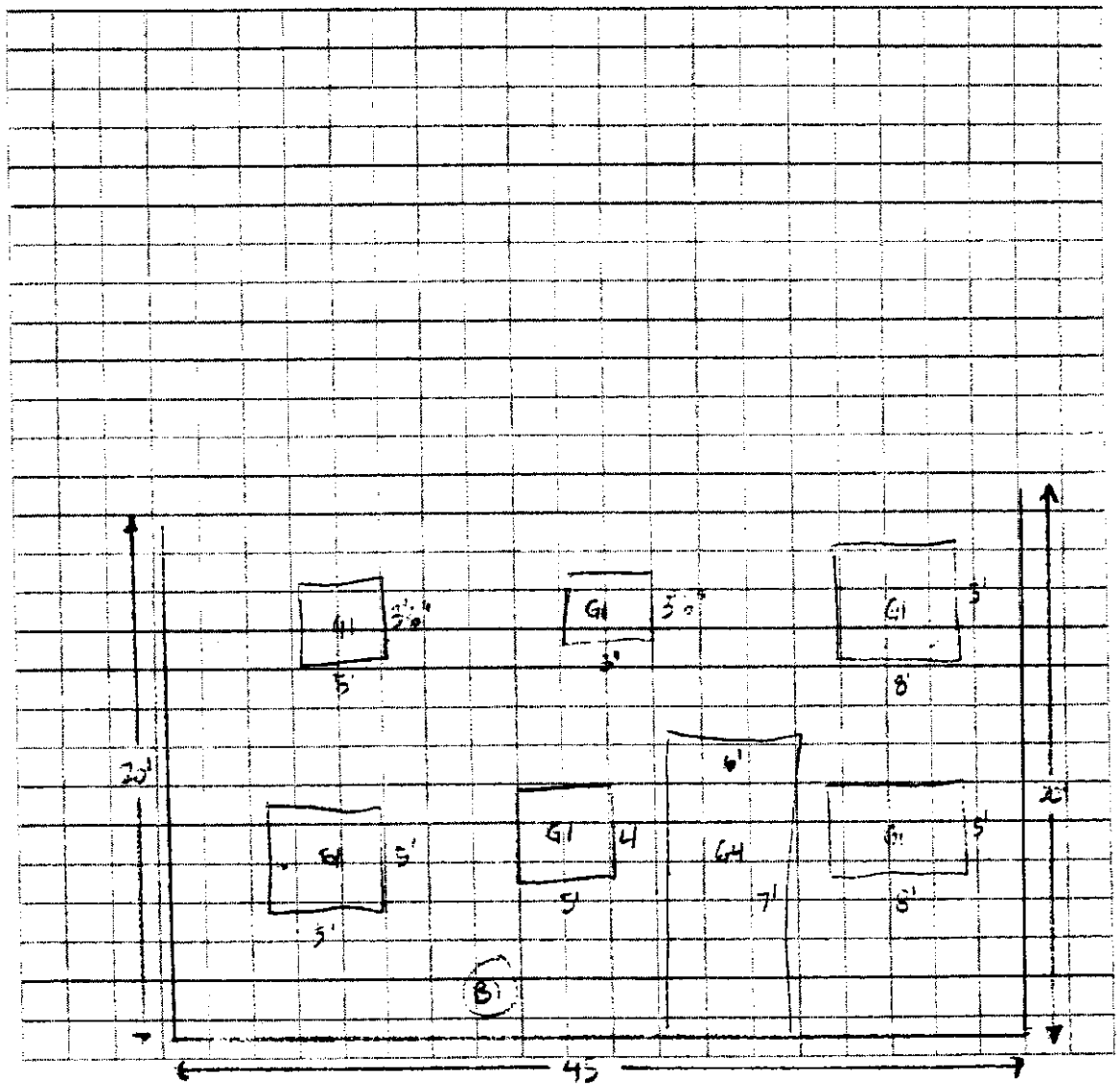
FRONT



Elevation Sketch #2

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

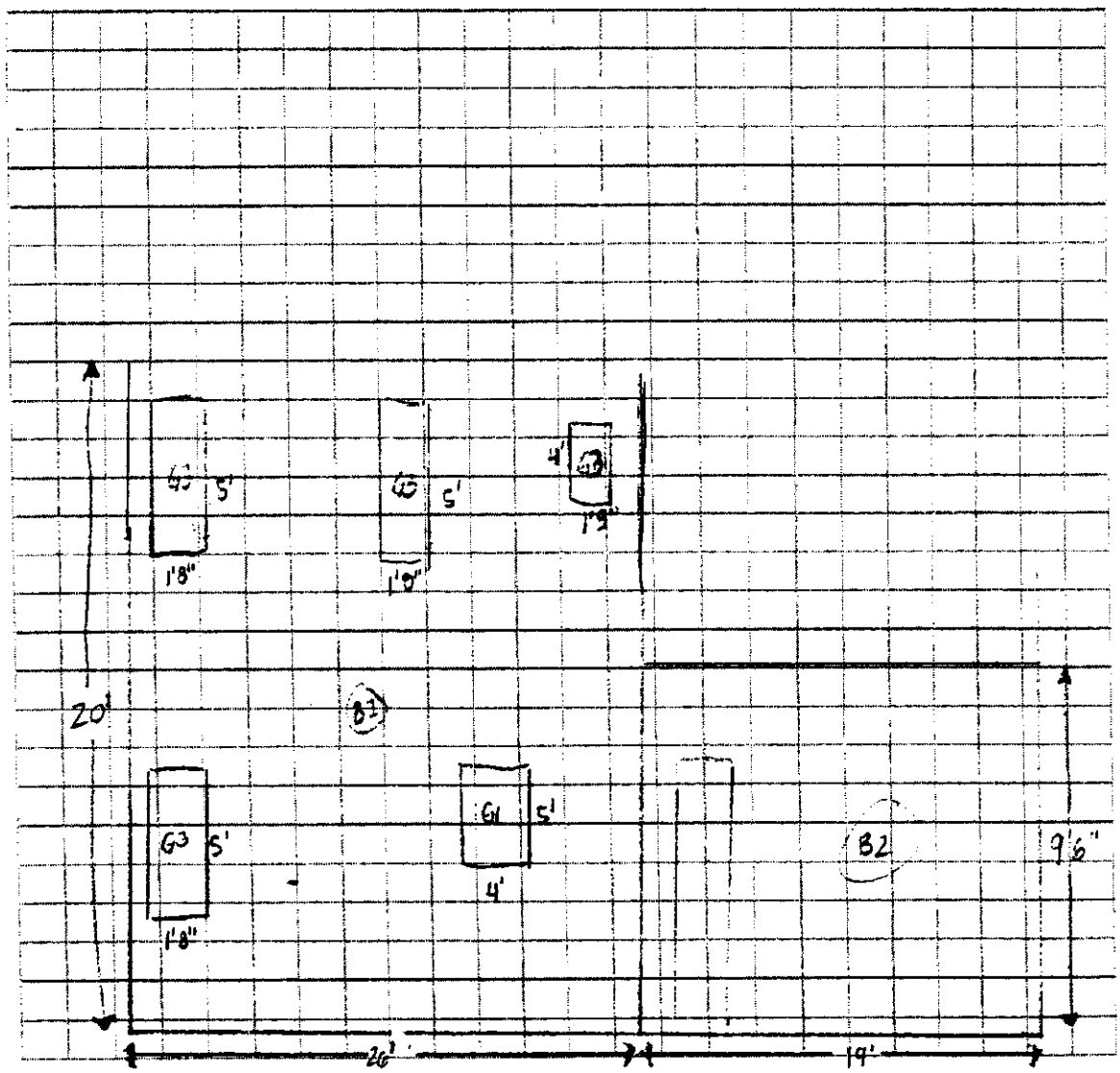
BACK



Elevation Sketch #3

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

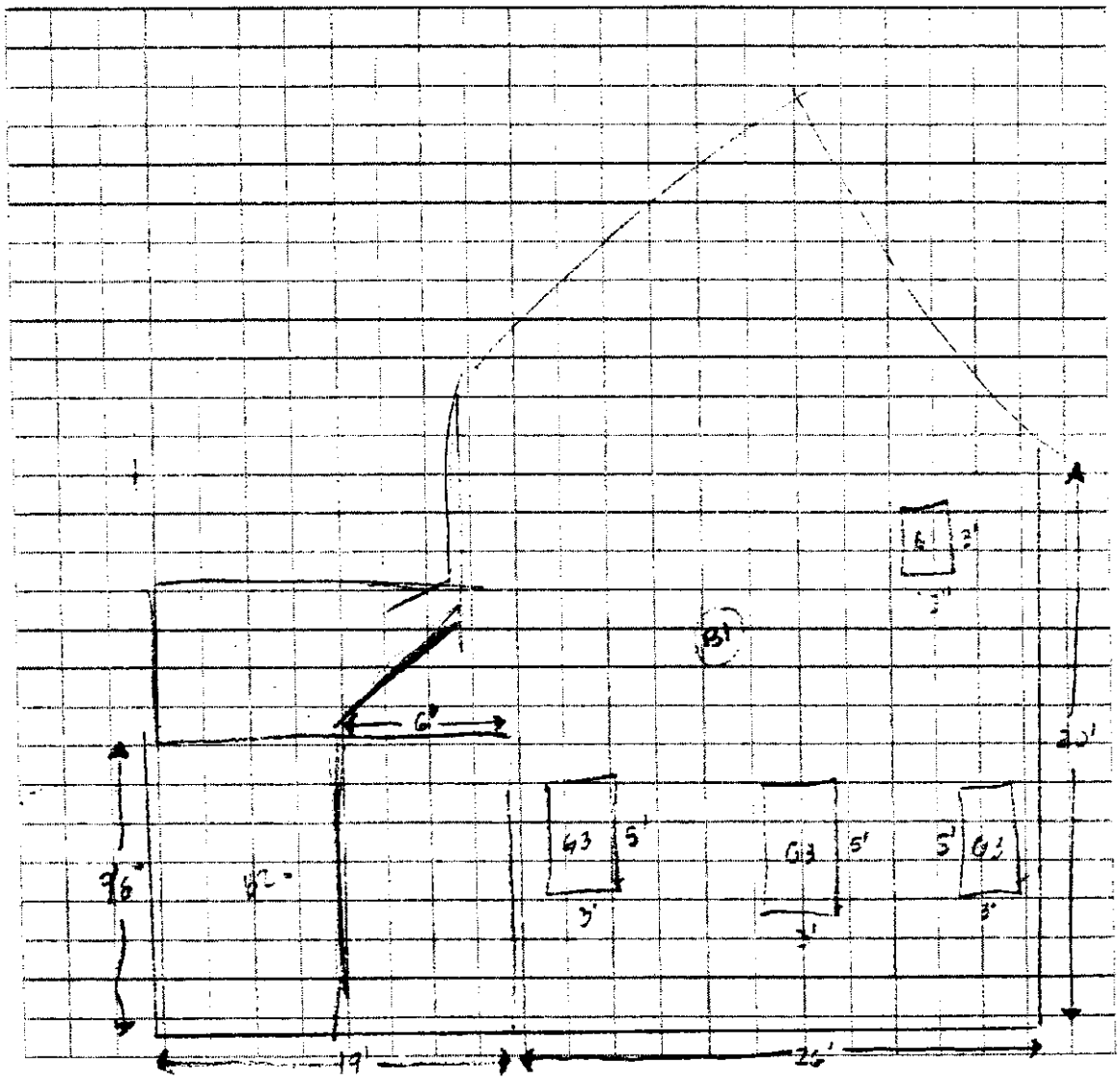
LEFT



Elevation Sketch #4

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

RIGHT



Heating Systems

	System #1	*System #2*
System Type Code*	2	
Fuel Code	G	
Quantity	1	
Age (in years - round to whole number)	2	
Programmable Thermostat (Y / N)	Y	
Equipment Location Code	4	
Manufacturer		
Model #		
Serial #		
Output (Btu)		
Input (Btu)		
Input (kW)		
Volts/ Phase/ Rated Amps (RLA)		
Auxiliary Heat, kW		
AFUE or HSPF or COP (circle one)		
Area serving (1st floor, 2nd floor, etc.)	1st & 2nd	

*Note: If System Type Code is 8, explain the usage pattern. Example: Gas furnace rarely used, fireplace - 4hr/day, portable electric heaters - 2 hr/day.

System Type Codes	*Fuel Codes*	*Location Codes*
1. DX Heat Pump	E = Electric	1. Conditioned Space
2. Central Forced Air Furnace	G = Natural Gas	2. Garage
3. Electric Resistance Baseboard	W = Wood	3. Outside
4. Radiant Heater	C = Coal	4. Other Unconditioned Space
5. Central Forced Air Packaged Unit --Gas Pack	P = LPG	
6. Portable Heaters	O = Oil	
7. Fireplace/Wood Burning Stove	S = Steam	
8. Combination/Addition of a secondary system	M = Other	

Cooling Systems

	System #1	*System #2*
System Type Code	1	
Quantity	1	
Age (in years - round to whole number)	2	
Programmable Thermostat? (Y/N)	Y	
Outdoor Unit		
Manufacturer	York	
Model Number	H1A048S06B	
Serial Number	EAGM012770	
Indoor Fan Coil		
Manufacturer		
Model Number		
Power & Efficiency Characteristics		
Output (Btuh)		
Input (kW)		
Volts/ Phase/ Rated Amps (RLA)	230/ 1/23.0	
SEER or		
EER or	7	
COP		

System Type Codes	Fuel Codes
1. Central Forced Air System --AC only	E = Electric
2. Central Forced Air Packaged Unit --Gas Pack	G = Natural Gas
3. Heat Pump	W = Wood
4. Window or Wall AC unit	C = Coal
5. Central Evaporative Cooler	P = LPG
6. Other	O = Oil
	S = Steam
	M = Other

Outdoor Lighting

	Number	Operation, hr/day-bulb
Incandescent Bulbs	2	2
Compact Fluorescent Bulbs (CFL)	0	
Security Lamps (Metal Halide/Mercury Vapor)	0	0

Ducts

Duct Type (0-none, 1-flexed, 2-sheet metal, 3-other)	1
Duct Insulation R-value	4
Describe Duct Insulation Condition (1-good, 2-fair, 3-poor)	1
Return air (1- bend only, 2-ducted return, 3-none)	1

Percent of Supply Duct Located in...

Conditioned Space	25
Vented Attic Space	75
Vented Crawl Space	
Open Space (or Garage)	
Slab on Grade	

Percent of Return Duct Located in...

Conditioned Space	
Unconditioned Space	100

Is Duct Header (connection to AC unit) Taped? (Y/N)	Y
Describe duct taping (0=none, 1=duct tape, 2=mastic, 3=butyl, 4=screws/mechanical only)	3

Thermostat Settings

Primary **cooling** system thermostat settings (°F) during July and August.

Time periods *Off = 99°*	Weekdays #1 Unit	Weekend #1 Unit	Weekday #2 Unit	Weekend #2 Unit
6 am to 10 am (morning)	99	99	/	/
10 am to 6 pm (day)	78	78	/	/
6 pm to 10 pm (evening)	80	80	/	/
10 pm to 6 am (night)	99	99	/	/

Primary **heating** system thermostat settings (°F) during December and January.

Time periods *Off = 50°*	Weekdays #1 Unit	Weekend #1 Unit	Weekday #2 Unit	Weekend #2 Unit
6 am to 10 am (morning)	68	68	/	/
10 am to 6 pm (day)	77	77	/	/
6 pm to 10 pm (evening)	77	77	/	/
10 pm to 6 am (night)	66	66	/	/

Refrigerators

	Type	Cond. Space (Y/N)	Size Cu. Ft.	Watts (1022 kW/yr)	Amps	Age	Months/Year Used
Unit 1	1	Y	24			2	12
Unit 2							
Unit 3							

Type codes:
1. Auto Defrost Side by Side
2. Auto Defrost Top / Bottom
3. Auto Defrost Single Door
4. Manual Defrost Single Door

Freezers

	Type	Cond. Space (Y/N)	Size Cu. Ft.	Watts	Amps	Age	Months/Year Used
Unit 1							
Unit 2							
Unit 3							

Type codes:
1. Auto Defrost Upright
2. Auto Defrost Chest
3. Manual Defrost Upright
4. Manual Defrost Chest

Cooking

	Fuel (Elec/Gas/Prop)	Meals* Per Week	Number (Ovens/Burners)
Oven Fuel (E/G/P)	G	1	1
Range Fuel (E/G/P)	G	14	4
Microwave Oven		8	1

*Note: Enter the total number of meals. The maximum is 3 meals/day or 21 meals/week.

Television

Number of televisions	2
Number of TV set hours per day (# TV * # Hours)	4

Dishwasher

Use Electric Dishwasher (Y/N)	Y
Uses energy saving cycle (Y/N)	Y
Total loads per week	14
Number of loads weekdays between 10am - 6pm	1

Indoor Lighting

	Indoor
Total Number of Bulbs (including Fluorescent bulbs)	54
Number of Compact Fluorescent Bulbs (CFL)	
CFL hardwired	0
CFL screw-in	3
Number of Fluorescent Tubes	2
Number of CFLs that were installed when you moved in?	
CFL hardwired	0
CFL screw-in	3

Hot Water Heating

Make	State Industry		
Model	PAV 40 NOCT 970 52C		
Fuel Code	G	Located in conditioned space? (Y/N)	N
Tank Capacity (gallons)	40	Input Rating (kW or kBtuh)	35
Temperature Setting* (°F)	140	Insulating Blanket? (Y/N)	Y
Is there a Timeclock (Y/N)	N	Are visible pipes insulated? (Y/N)	Y

**Guages usually scale between 120°F and 160°F, so LO=120°F, MED=140°F, and HI=160°F.*

Laundry

Use Clothes Washer? (Y/N)	Y
Number of hot / warm water loads per week	7
Use Clothes Dryer? (Y/N)	Y
Clothes Dryer Fuel Code	E
Is Dryer/Washer located in conditioned space? (Y/N)	Y
Number of dryer loads per week	7
Gas Stub in Laundry Area? (Y/N)	Y

Fuel Codes
E = Electric
G = Natural Gas
P = LPG
S = Solar
M = Other

Pool

Swimming Pool? (Y/N) [N]

Filter Pump

Filter on timer? (Y/N) [ ]

Filter hours per day (summer) [ ][ ]

Filter hours per day (winter) [ ][ ]

Filter pump size (kW) or (HP) [ ][ ] kW [ ][ ] HP

Pool Heater

Heater Fuel Type Code* [ ], [ ]

Heater Capacity (kW) or (HP) [ ][ ] kW [ ][ ] HP

Heater Use (1-never, 2-seldom, 3-frequent, 4-always) [ ]

*Note: Indicate combination of fuel types. Sample: (G,S) means Gas and Solar. Describe the percent use allocated to each fuel type.

Spa

Spa or hot tub? (Y/N) [N]

Spa location (1-outdoor, 2-indoor) [ ]

Spa uses per week [ ][ ]

Filter

Filter on timer? (Y/N) [ ]

Filter hours per day (summer) [ ][ ]

Filter hours per day (winter) [ ][ ]

Filter pump size (kW) or (HP) [ ][ ] kW [ ][ ] HP

Heater

Spa Heater Fuel Type Code [ ] :

If electric, ON continuously? (Y/N) [ ]

If gas, hours ON before each use [ ][ ]

Heater ON, hours per week (summer) [ ][ ]

Heater ON, hours per week (winter) [ ][ ]

Fuel Codes			
E =	Electric	P =	LPG
G =	Natural Gas	O =	Oil
W =	Wood	S =	Steam
C =	Coal	M =	Other

RESIDENT QUESTIONNAIRE

1. Which of the following equipment or services are used in this home?

	Yes	No	(If Yes) How Many	Equipment Use, hr/week
Home Office Equipment				
Personal computer	☑	☐	—	—
Computer printer	☑	☐	—	—
Fax machine	☑	☐	—	—
Copier (other than fax)	☐	☑	—	—
Miscellaneous				
Heated water bed	☐	☑	—	—
Small kitchen appliances	☑	☐	2	1/per wk
Gas fireplace	☐	☑	—	—
Welding equipment	☐	☑	—	—
Medical equipment	☐	☑	—	—
Well pump	☐	☑	—	—
Other (list) Hepa filter.	☑	☐	—	2-3/per wk
Other (list) _____	☐	☐	—	—

2. Fan Usage in Summer

	Don't Have	Rarely	Sometimes	Often
Portable Fans	☐	☑	☐	☐
Ceiling Fans	☐	☐	☐	☑
Attic Fan	☑	☐	☐	☐
Whole House Fan	☑	☐	☐	☐

3. How many people, including yourself, live in this home? 04

4. How many people living in your home are:

		Number
Preschool	(under 6)	02
School Age	(6-17)	
Adult -	18-34	02
	35-59	
	60-74	
	Over 74	

5. How many people occupy the home from 10 a.m. to 6 p.m. on typical weekdays?

	Number
Winter (Dec - Feb).....	04
Spring (Mar-May).....	04
Summer (Jun-Aug)	04
Fall (Sep-Nov).....	04

6. Is your home used as a primary work location?
   1. Yes ☐
   2. No ☑

7. Does someone occupy the home at least 10 months per year?
   1. Yes ☑
   2. No ☐

8. Did you (will you) vacation away from home at least one week this summer?
   1. Yes ☑
   2. No ☐

9. Is the home part of a subdivision?
   1. Yes ☑
   2. No ☐

10. Name of the builder/developer who constructed the home: Graystone

11. Do you own or rent?
   1. Own ☑
   2. Rent ☐

If you RENT then skip to Question 27

12. Check the approximate purchase price of home:

Under $100,000.....1	☐
$100,000-$149,999 2	☐
$150,000-$199,999 3	☐
$200,000-$249,999 4	☑
$250,000-$299,999 5	☐
$300,000-$349,999 6	☐
$350,000-$399,999 7	☐
$400,000 or more 8	☐

13. Please rank the following factors important in the decision to buy your home, with 1 for the most important to 7 for the least important:

Price 1	2
Location 2	1
House Size 3	5
Appearance 4	4
Home Layout 5	3
Energy Efficiency 6	6
Schools 7	7

14. Was energy efficiency an important consideration in your home purchase decision?

1. Yes ✓
2. No

15. Have you heard of the *PG&E Comfort Home Program*?

1. Yes ✓
2. No
3. Don't Know

If you are aware of the *PG&E Comfort Home Program*,

16. How did you first learn about the PG&E Comfort Home Program?

PG&E	
Builder	
Realtor	✓
Advertisements	✓
Word-of-mouth	
Other (describe) _____	

17. Is your home a *PG&E Comfort Home*?

1. Yes
2. No
3. Don't Know ✓

If your home is a *PG&E Comfort Home*,

18. Were you specifically looking to purchase a PG&E Comfort Home?

1. Yes
2. No ✓

19. What features of your home are energy efficient?

windows
air conditioning TC ~~west~~ walls.
refrigerator

20. Would you be willing to pay more for a new home with cost effective energy efficient features? (Cost effective energy efficient features usually produce savings on your energy bill that over time will pay for the higher costs of the home.)

1. Yes ☑
2. No ☐

21. IF YES: How much more would you be willing to pay for a new home with cost effective energy efficient features?

$0	1 ☐
$0-500	2 ☐
$501-1000	3 ☑
$1001-2000	4 ☐
$2001-3000	5 ☐
$3001-5000	6 ☐
$5001-10,000	7 ☐
Other (write in) _____	8 ☐

22. Did you use any special energy efficient related loan packages to help with the financing of your new home?

1. Yes ☐
2. No ☑

23. IF YES: What type of package did you use? _____

24. IF NO: Were you aware that energy efficient loan packages were available?

1. Yes ☐
2. No ☑

25. During your efforts to purchase a new home, were you aware that some homes are built more energy efficient than others?

1. Yes ☑
2. No ☐

26. IF YES: From what source did you learn about the different levels of energy efficiency in new homes?

Realtor	1 ☐
PG&E	2 ☐
New Home Advertising (Newspaper, Site Brochure)	3 ☑
Financial Institution	4 ☐
Other (list) _____	5 ☐

27. Have you used PG&E rebate coupons in the purchase of any of the following:

27A. Natural gas clothes dryer	1. Yes ☐	2. No ☑
27B. Energy efficient clothes washer	1. Yes ☐	2. No ☑
27C. Energy efficient refrigerator	1. Yes ☐	2. No ☑

28. What is the highest education level for the head of the household:

Some high school 1	
High school graduate 2	
Some college/Junior college graduate 3	✓
College graduate 4	
Graduate degree 5	

29. Approximate household income category:

Under $25,000 1	
$25,000-$49,999 2	
$50,000-$74,999 3	
$75,000-$99,999 4	✓
$100,000-$149,999 5	
$150,000 or more 6	

30. Have you heard of the Energy Star New Homes Program that is being provided through the U. S. Environmental Protection Agency?

1. Yes	✓
2. No	

31. IF YES: From what source did you learn about the different levels of energy efficiency in new homes?

Realtor 1	
New Home Advertising (Newspaper, Site Brochure) 2	✓
Financial Institution 3	
Other (list) _____ 4	

32. IF YES: Please describe what you know about this program:

Rebates are given.

END OF SURVEY, THANK YOU FOR PARTICIPATING

Duct Pressure Testing

Site Control Number	655 [illegible] 3
Date	10.8.99
Surveyor(s)	Solar
Address	1121 Alder Creek Way, Brentwood

Fan connection location	ΔP_{duct}	Ring Number	Duct Leakage Flow cfm
2nd floor hall ceiling	25	1	191

Air Handler Location *(closet, attic, crawlspace, garage, etc.)*	attic
House Floor Area	2220 ft
Number of supply registers	14
Number of return registers	1

Notes:

House 6563447

ROCKLIN. CA 95765

Dwelling Characteristics

Dwelling Type	1
Age of Home, years	01
Number of Levels	2
Estimated Conditioned Area, SF	3000
Estimated Unconditioned Area, SF	680
Weather-stripping around doors? (Y/N)	Y
Number of Bedrooms	5
Total Number of Rooms (excluding hallways, bathrooms, basement, closets, and any rooms not used as living space)	9

Dwelling Type Codes
1. Single-Family Stand Alone
2. Single-Family Attached
3. Multi-Family
4. Mobile Home
5. Other

Walls

Wall Reference Number	B1	B2	B3	B4
Wall Construction Code	2	2		
Wall Siding Type Code	3	7		
Percent Wall Below Grade	0	0		
Wall Thickness, inches	7	7		
Wall Insulation R-value	13	13		
Wall Percent Insulated	100	100		
Wall Color Code (1-dark, 2-medium, 3-light)	3	3		

1. No Exterior	1. Wood Siding
2. 2"X4" Wood Frame	2. Masonry Siding
3. 2"X4" Wood Frame w/ insul. sheet	3. Stucco / Plaster
4. 2"X6" Wood Frame	4. Combination Wood + Masonry / Stucco
5. 2"X4" Metal Frame	5. Metal Siding
6. 2"X6" Metal Frame	6. Vinyl Siding
7. Concrete block	7. Other STUCCO
8. Brick wall	
9. Other _____	

Windows

Window Reference	G1	G2	G3	G4
Window Type Code	1	1	1	1
Number of Panes	2	2	2	2
Frame Type Code	3	3	3	3
Glazing Type Code	1	1	6	1
Interior Shading Code	2	1	0	2
Exterior Shading Code	0	0	0	1

Same as 1

Window Reference	G5	G6	G7	G8
Window Type Code				
Number of Panes				
Frame Type Code				
Glazing Type Code				
Interior Shading Code				
Exterior Shading Code				

1. Window (opens) 2. Window (fixed) 3. Skylight 4. Door	1. Wood 2. Metal 3. Vinyl	1. Clear Glass 2. Tinted Glass 3. Reflective Film 4. Clear w/ Low-E 5. Tinted w/ Low-E 6. Opaque	0. None 1. Drapes 2. Blinds	0. None 1. Building 2. Trees/Foliage 3. Fence 4. Sunscreen or Awning

Ceilings*

Ceiling Reference	C1	C2	C3
Estimated Ceiling Area, SF	1670		
Description (1-attic above, 2-vaulted, 3-flat no attic)	1		
Insulation			
Insulation Type Code	4		
Insulation R-value	30		
Insulation Thickness, inches	14		
Percent Insulated, %	100		
Describe Insulation Condition (1-good, 2-fair, 3-poor)	2 UNEVEN		
Skylights? (Y/N)	N		
Estimated Skylight Area, SF			
Window Reference (G1, G2, etc.)			

*Note: Identify the ceiling types on the floor plan (page 7) with a proper code (e.g. C1, C2).

Roof

Roof Exterior Color (Dark/Med/Light)	D
Roof Slope (1-almost flat, 2-average incline, 3-very steep)	2

0. None
1. Fiberglass (batt)
2. Blown-in Cellulose
3. Rigid Board (isocyanurate/polystyrene)
4. Other BLOWN FIBERGLASS

Floors*

Floor Reference	F1	F2	F3
Estimated Floor Area, SF	1090	616	616
Floor Type Code	2	2	3
Insulation R-Value	0	0	11
Percent of the Floor Tiled or Vinyl	40	0	10
Percent of the Floor Carpeted	60	0	90

Raised Floor Only

Crawl Space Height (ft.)			
Crawl Space Wall Construction Type			
Is Crawl Space Vented? (Y/N)			
Crawl Space Wall Insulation R-Value			

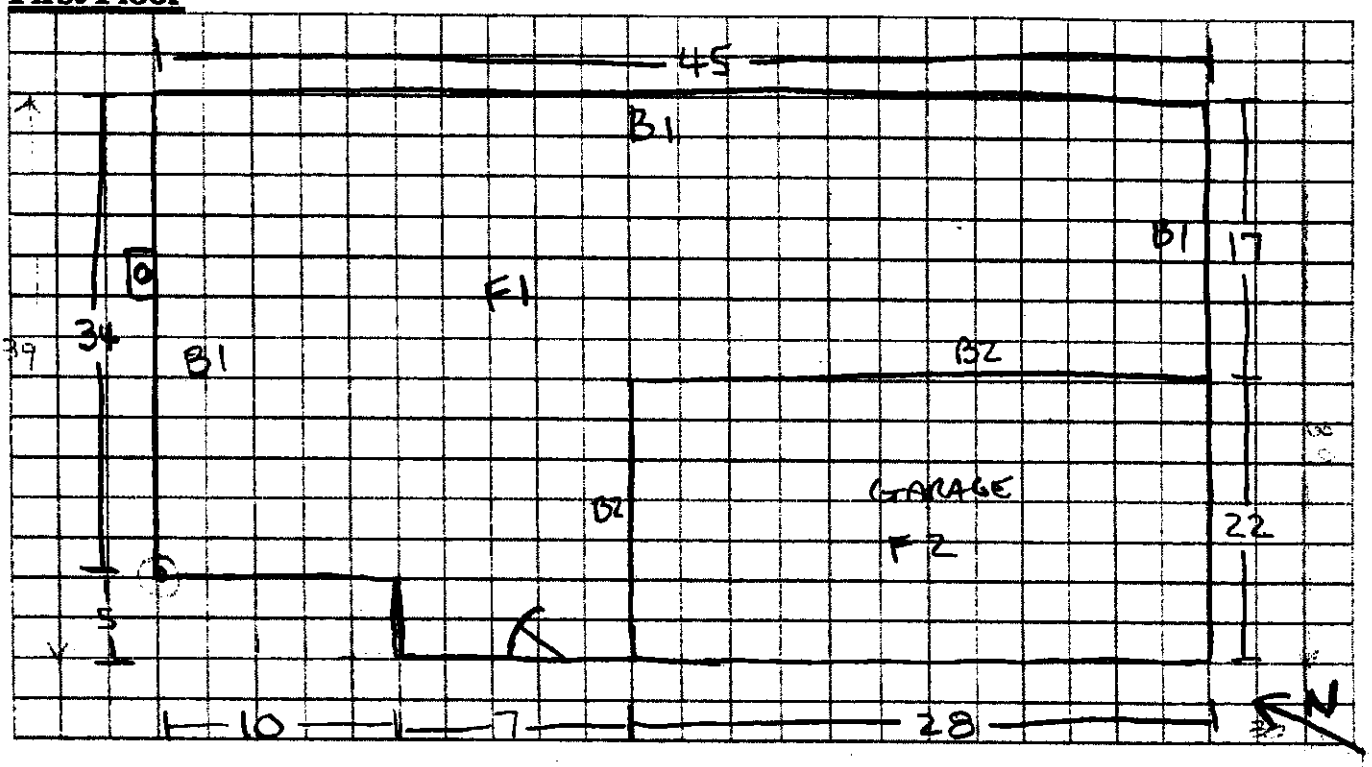
*Note: Draw the floor outlines on the floor plan (next page) and identify with a proper code (e.g. F1, F2..).

1. Raised floor	1. Framed
2. Slab-on-grade	2. Concrete
3. Floor over Garage (or other unconditioned space)	3. Other: _____

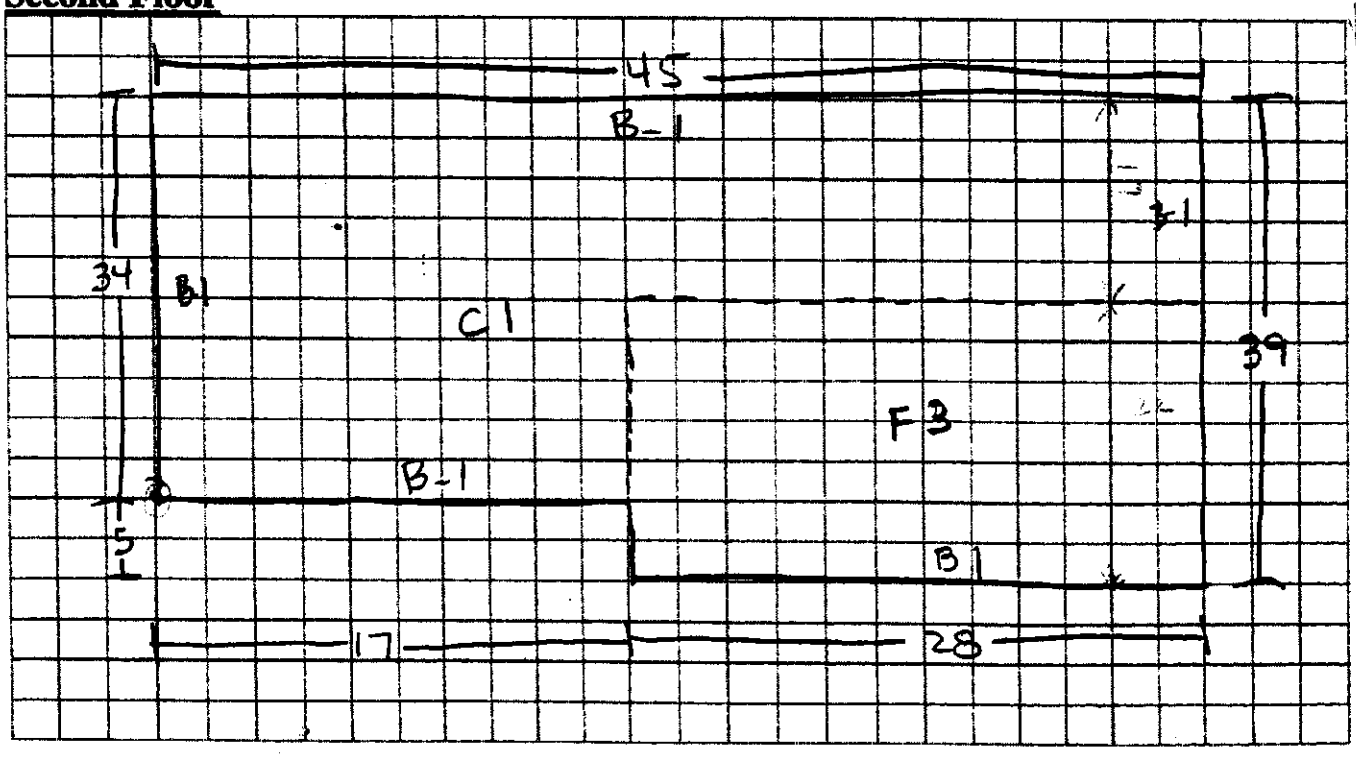
Floor Plan Sketches

① Include a Wall Reference Number for each wall (e.g., B1). The Reference Number will be the same for walls with the same construction characteristics. ② Record the outer length of each wall. ③ Indicate North with an arrow. ④ Identify all ceilings with the proper code (e.g., C1) and mark cathedral ceilings with cross-hatching. ⑤ Identify floors over unconditioned spaces (i.e., ground floor, and rooms over the garage). ⑥ Mark the location of the garage.

First Floor



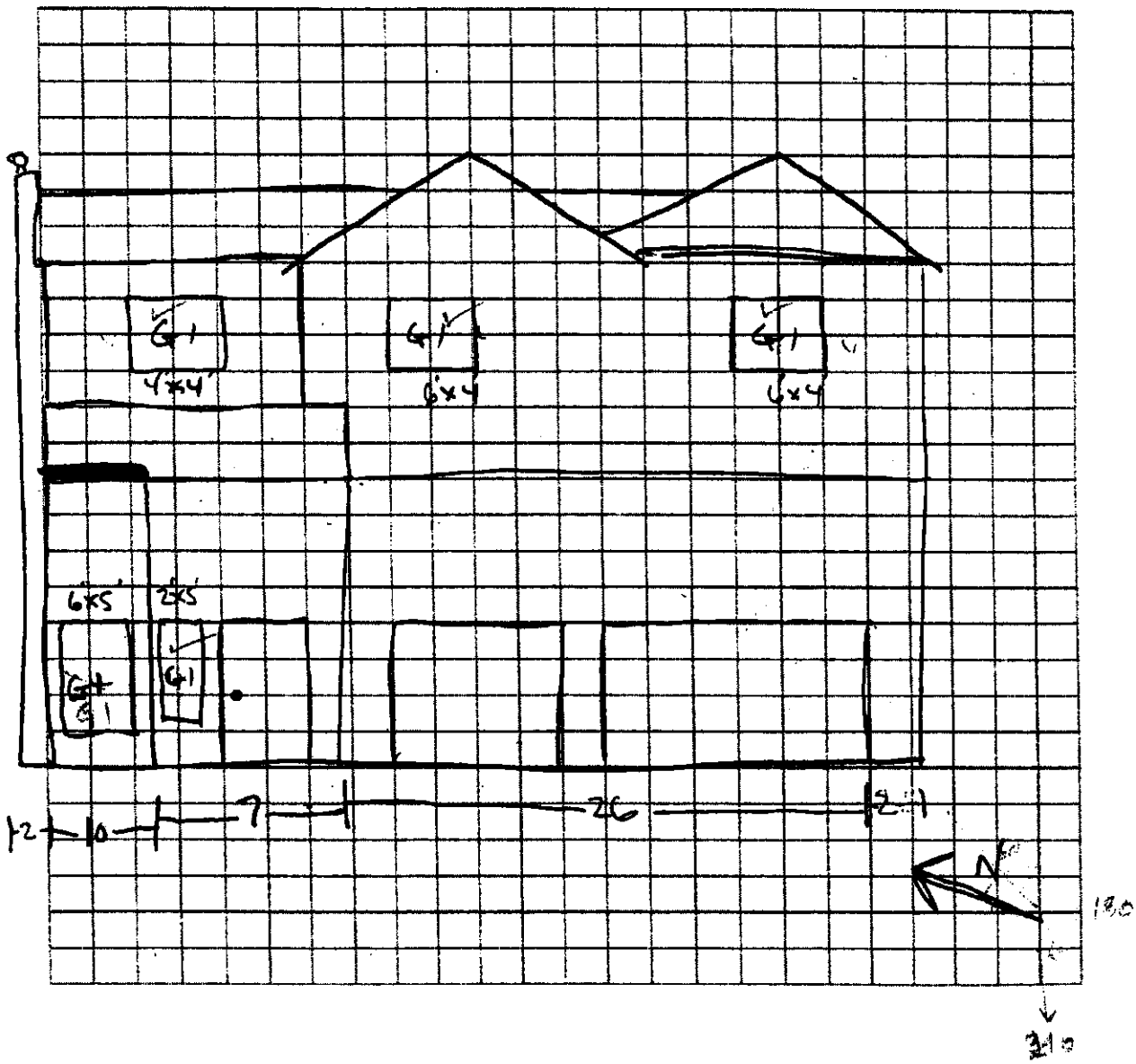
Second Floor



Elevation Sketch #1

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

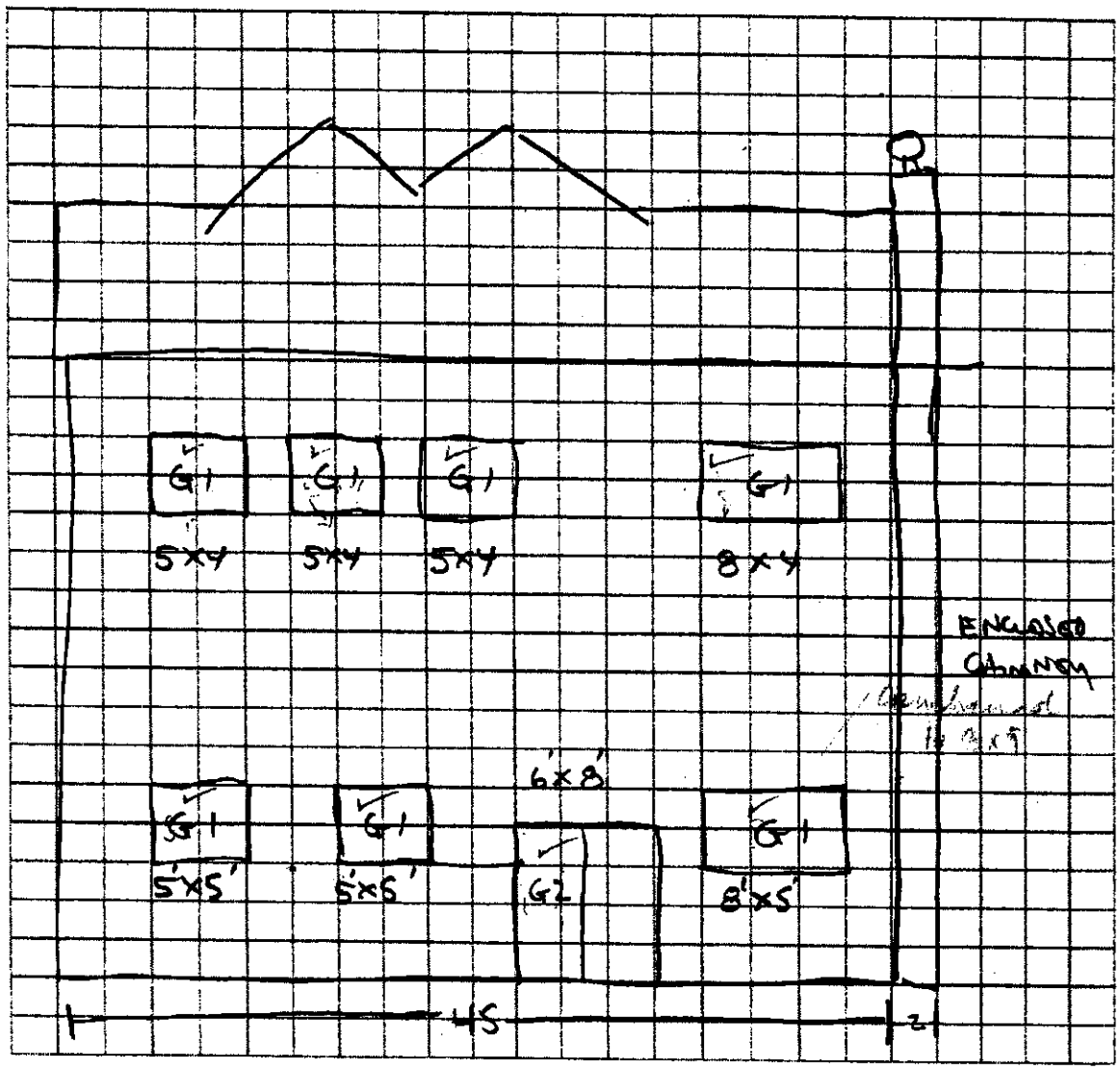
FRONT



Elevation Sketch #2

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

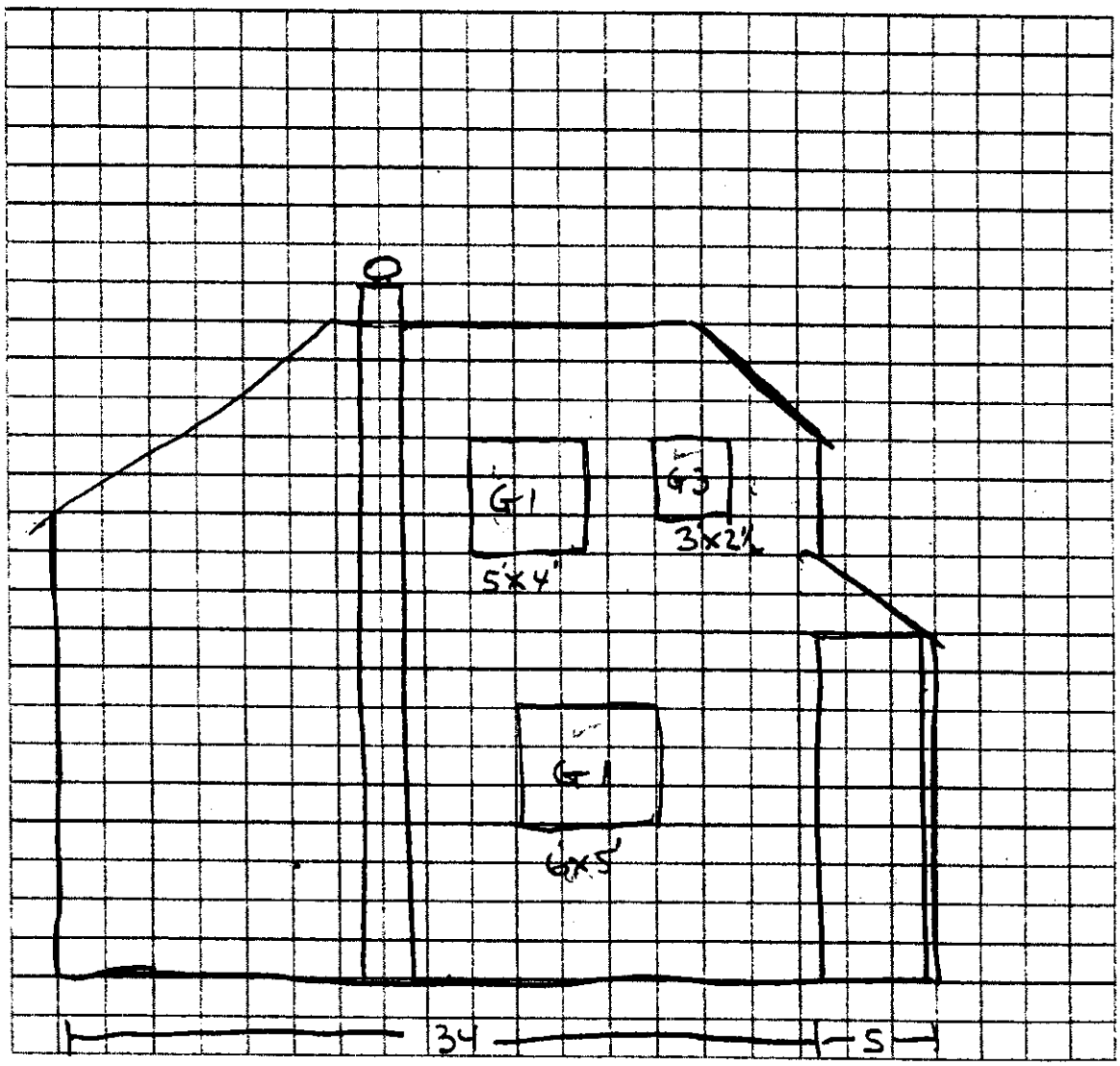
BACK



Elevation Sketch #3

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

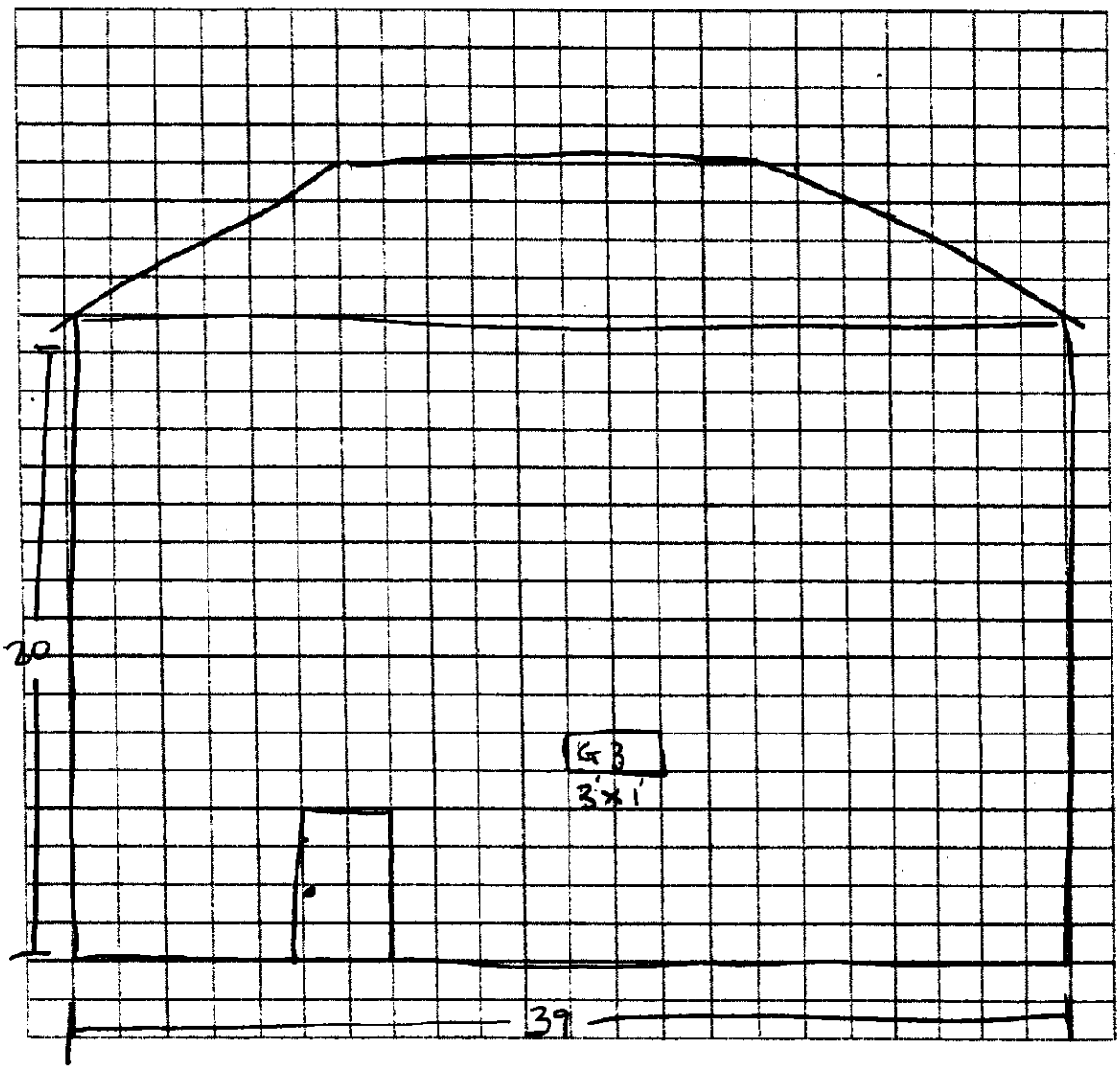
LEFT



Elevation Sketch #4

① Sketch each elevation separately. ② Record the height of exterior walls. ③ For each elevation show the window locations, mark the Window Reference (e.g., G1) and record the window height and width. ④ For each significant overhang, mark the location with a dark horizontal line passing over each shaded window.

RIGHT



Heating Systems

	System #1	*System #2*
System Type Code*	2	
Fuel Code	G	
Quantity	1	
Age (in years - round to whole number)	01	
Programmable Thermostat (Y / N)	Y	
Equipment Location Code	4	
Manufacturer	MASTIC	
Model #	GMP 100-5	
Serial #	971260352 2	
Output (Btu)	MASTIC	
Input (Btu)	MASTIC	
Input (kW)	MASTIC	
Volts/ Phase/ Rated Amps (RLA)	120V	
Auxiliary Heat, kW	0	
AFUE or HSPF or COP (circle one)	MASTIC	
Area serving (1st floor, 2nd floor, etc.)	1ST & 2ND Floor	

*Note: If System Type Code is 8, explain the usage pattern. Example: Gas furnace rarely used, fireplace - 4hr/day, portable electric heaters - 2 hr/day.

MASTIC COVERED DATA – UNABLE TO REMOVE PANEL SEALED W/ MASTIC

1. DX Heat Pump	E = Electric	1. Conditioned Space
2. Central Forced Air Furnace	G = Natural Gas	2. Garage
3. Electric Resistance Baseboard	W = Wood	3. Outside
4. Radiant Heater	C = Coal	4. Other Unconditioned Space
5. Central Forced Air Packaged Unit –Gas Pack	P = LPG	
6. Portable Heaters	O = Oil	
7. Fireplace/Wood Burning Stove	S = Steam	
8. Combination/Addition of a secondary system	M = Other	

Cooling Systems

	System #1	System #2
System Type Code	1	
Quantity	1	
Age (in years - round to whole number)	01	
Programmable Thermostat? (Y/N)	Y	
Outdoor Unit	ENERGY STAR RATING STICKER	
Manufacturer	GOODMAN	
Model Number	CKJ60-1C	
Serial Number	9706130941	
Indoor Fan Coil		
Manufacturer		
Model Number	H61F	
Power & Efficiency Characteristics	9710025657 SERIAL #	
Output (Btuh)	MASTIC	
Input (kW)		
Volts/ Phase/ Rated Amps (RLA)		
SEER or		
EER or		
COP		

MASTIC CONDENSING COIL & ENCLOSED - UNABLE TO ACCESS

1. Central Forced Air System --AC only	E = Electric
2. Central Forced Air Packaged Unit --Gas Pack	G = Natural Gas
3. Heat Pump	W = Wood
4. Window or Wall AC unit	C = Coal
5. Central Evaporative Cooler	P = LPG
6. Other	O = Oil
	S = Steam
	M = Other

Outdoor Lighting

	Number	Operation, hr/day-bulb
Incandescent Bulbs	3	01
Compact Fluorescent Bulbs (CFL)	0	
Security Lamps (Metal Halide/Mercury Vapor)	0	0

Ducts

Duct Type (0-none, 1-flexed, 2-sheet metal, 3-other)	1
Duct Insulation R-value	4
Describe Duct Insulation Condition (1-good, 2-fair, 3-poor)	1
Return air (1- bend only, 2-ducted return, 3-none)	2
Percent of Supply Duct Located in...	
Conditioned Space	40
Vented Attic Space	60
Vented Crawl Space	
Open Space (or Garage)	
Slab on Grade	
Percent of Return Duct Located in...	
Conditioned Space	1
Unconditioned Space	99
Is Duct Header (connection to AC unit) Taped? (Y/N)	Y

MASTIC + SCREWS & TAPE

Thermostat Settings

Primary **cooling** system thermostat settings (°F) during July and August.

Time periods *Off = 99°*	Weekdays #1 Unit	Weekend #1 Unit	Weekday #2 Unit	Weekend #2 Unit
6 am to 10 am (morning)	80	80		
10 am to 6 pm (day)	80	80		
6 pm to 10 pm (evening)	80	80		
10 pm to 6 am (night)	80	80		

Primary **heating** system thermostat settings (°F) during December and January.

Time periods *Off = 50°*	Weekdays #1 Unit	Weekend #1 Unit	Weekday #2 Unit	Weekend #2 Unit
6 am to 10 am (morning)	65	65		
10 am to 6 pm (day)	65	65		
6 pm to 10 pm (evening)	65	65		
10 pm to 6 am (night)	65	65		

Refrigerators

	Type	Cond. Space (Y/N)	Size Cu. Ft.	Watts	Amps	Months/Year Age	Used
Unit 1	1	Y	27		7	01	12
Unit 2	4	N	2			06	12
Unit 3							

6.5

1. Auto Defrost Side by Side
2. Auto Defrost Top / Bottom
3. Auto Defrost Single Door
4. Manual Defrost Single Door

Freezers

	Type	Cond. Space (Y/N)	Size Cu. Ft.	Watts	Amps	Months/Year Age	Used
Unit 1	1	N	17		6	10	12
Unit 2							
Unit 3							

6.4

1. Auto Defrost Upright
2. Auto Defrost Chest
3. Manual Defrost Upright
4. Manual Defrost Chest

Cooking

	Fuel (Elec/Gas/Prop)	Meals* /Week	Size (kW or kBtuh)	
Oven Fuel (E/G/P)	E	0	9	
Range Fuel (E/G/P)	G	5		3 Conv 1 Rad Burners
Microwave Oven		4	2	

*Note: Enter the total number of meals. The maximum is 3 meals/day or 21 meals/week.

Television

Number of televisions	5
Number of TV set hours per day (# TV * # Hours)	8

Dishwasher

Use Electric Dishwasher (Y/N)	Y
Uses energy saving cycle (Y/N)	N
Total loads per week	3
Number of loads weekdays between 10am - 6pm	0

Indoor Lighting

	Indoor
Total Number of Bulbs (including Fluorescent bulbs)	89
Number of Compact Fluorescent Bulbs (CFL)	
CFL hardwired	0
CFL screw-in	0
Number of Fluorescent Tubes	3
Number of CFLs that were installed when you moved in?	
CFL hardwired	0
CFL screw-in	0

Hot Water Heating

Make	BLANKET + SWRAPS UNABLE TO ACCESS		
Model	BLANKET + SWRAPS UNABLE TO ACCESS		
Fuel Code	G	Located in conditioned space? (Y/N)	N
Tank Capacity (gallons)	50	Input Rating (kW or kBtuh)	
Temperature Setting (°F)	140	Insulating Blanket? (Y/N)	Y
Is there a Timeclock (Y/N)	N	Are visible pipes insulated? (Y/N)	Y

Laundry

Use Clothes Washer? (Y/N)	Y
Number of hot / warm water loads per week	5
Use Clothes Dryer? (Y/N)	Y
Clothes Dryer Fuel Code	G
Is Dryer/Washer located in conditioned space? (Y/N)	Y
Number of dryer loads per week	5
Gas Stub in Laundry Area? (Y/N)	Y

E = Electric
G = Natural Gas
P = LPG
S = Solar
M = Other

Pool

Swimming Pool? (Y/N) [N]

Filter Pump

Filter on timer? (Y/N) [ ]

Filter hours per day (summer) [ ][ ]

Filter hours per day (winter) [ ][ ]

Filter pump size (kW) or (HP) [ ][ ] kW [ ][ ] HP

Pool Heater

Heater Fuel Type Code* [ ], [ ]

Heater Capacity (kW) or (HP) [ ][ ] kW [ ][ ] HP

Heater Use (1-never, 2-seldom, 3-frequent, 4-always) [ ]

*Note: Indicate combination of fuel types. Sample: (G,S) means Gas and Solar. Describe the percent use allocated to each fuel type.

Spa

Spa or hot tub? (Y/N) [N]

Spa location (1-outdoor, 2-indoor) [ ]

Spa uses per week [ ][ ]

Filter

Filter on timer? (Y/N) [ ]

Filter hours per day (summer) [ ][ ]

Filter hours per day (winter) [ ][ ]

Filter pump size (kW) or (HP) [ ][ ] kW [ ][ ] HP

Heater

Spa Heater Fuel Type Code [ ]

If electric, ON continuously? (Y/N) [ ]

If gas, hours ON before each use [ ][ ]

Heater ON, hours per week (summer) [ ][ ]

Heater ON, hours per week (winter) [ ][ ]

E =	Electric	P =	LPG
G =	Natural Gas	O =	Oil
W =	Wood	S =	Steam
C =	Coal	M =	Other

RESIDENT QUESTIONNAIRE

1. Which of the following equipment or services are used in this home?

	Yes	No	(If Yes) How Many	Equipment Use, hr/week
Home Office Equipment				
Personal computer	☒	☐	3	42
Computer printer	☒	☐	2	1
Fax machine	☒	☐	1	1
Copier (other than fax)	☒	☐	3	1/2
Miscellaneous				
Heated water bed	☒	☐	1	
Small kitchen appliances	☒	☐	5	5
Gas fireplace	☒	☐	1	5
Welding equipment	☒	☐	1	1
Medical equipment	☐	☒	—	—
Well pump	☐	☒	—	—
Other (list) _____	☐	☒	—	—
Other (list) _____	☐	☒	—	—

2. Fan Usage in Summer

	Don't Have	Rarely	Sometimes	Often
Portable Fans	☐	☐	☒	☐
Ceiling Fans	☐	☐	☐	☒
Attic Fan	☒	☐	☐	☐
Whole House Fan	☒	☐	☐	☐

3. How many people, including yourself, live in this home? 04

4. How many people living in your home are:

		Number
Preschool	(under 6)	01
School Age	(6-17)	01
Adult -	18-34	01
	35-59	01
	60-74	
	Over 74	

5. How many people occupy the home from 10 a.m. to 6 p.m. on typical weekdays?

	Number
Winter (Dec - Feb).....	4
Spring (Mar-May).....	4
Summer (Jun-Aug)	4
Fall (Sep-Nov).....	4

6. Is your home used as a primary work location?
   1. Yes [ ]
   2. No [X]

7. Does someone occupy the home at least 10 months per year?
   1. Yes [X]
   2. No [ ]

8. Did you (will you) vacation away from home at least one week this summer?
   1. Yes [ ]
   2. No [X]

9. Is the home part of a subdivision?
   1. Yes [X]
   2. No [ ]

10. Name of the builder/developer who constructed the home: Lewis Homes

11. Do you own or rent?
   1. Own [X]
   2. Rent [ ]

If you RENT then skip to Question 27

12. Check the approximate purchase price of home:

Under $100,000.....1	[ ]
$100,000-$149,999 2	[ ]
$150,000-$199,999 3	[ ]
$200,000-$249,999 4	[X]
$250,000-$299,999 5	[ ]
$300,000-$349,999 6	[ ]
$350,000-$399,999 7	[ ]
$400,000 or more 8	[ ]

13. Please rank the following factors important in the decision to buy your home, with 1 for the most important to 7 for the least important:

Price 1	1
Location 2	3
House Size.....3	3
Appearance.....4	3
Home Layout.....5	2
Energy Efficiency.....6	3
Schools.....7	3

14. Was energy efficiency an important consideration in your home purchase decision?

1. Yes [ ]
2. No [X]

15. Have you heard of the *PG&E Comfort Home Program*?

1. Yes [X]
2. No [ ]
3. Don't Know [ ]

If you are aware of the *PG&E Comfort Home Program*,

16. How did you first learn about the PG&E Comfort Home Program?

PG&E.....	[ ]
Builder.....	[X]
Realtor.....	[ ]
Advertisements.....	[ ]
Word-of-mouth.....	[ ]
Other (describe) _____.....	[ ]

17. Is your home a *PG&E Comfort Home*?

1. Yes [X]
2. No [ ]
3. Don't Know [ ]

If your home is a *PG&E Comfort Home*,

18. Were you specifically looking to purchase a PG&E Comfort Home?

1. Yes [ ]
2. No [X]

19. What features of your home are energy efficient? Double panel windows, gas stove, gas dryer

20. Would you be willing to pay more for a new home with cost effective energy efficient features? (Cost effective energy efficient features usually produce savings on your energy bill that over time will pay for the higher costs of the home.)

1. Yes [X]
2. No [ ]

21. IF YES: How much more would you be willing to pay for a new home with cost effective energy efficient features?

$0 1	[ ]
$0-500 2	[X]
$501-1000 3	[ ]
$1001-2000 4	[ ]
$2001-3000 5	[ ]
$3001-5000 6	[ ]
$5001-10,000 7	[ ]
Other (write in) _____ 8	[ ]

22. Did you use any special energy efficient related loan packages to help with the financing of your new home?

1. Yes [ ]
2. No [X]

23. IF YES: What type of package did you use? _____

24. IF NO: Were you aware that energy efficient loan packages were available?

1. Yes [ ]
2. No [X]

25. During your efforts to purchase a new home, were you aware that some homes are built more energy efficient than others?

1. Yes [X]
2. No [ ]

26. IF YES: From what source did you learn about the different levels of energy efficiency in new homes?

Realtor 1	[X]
PG&E 2	[ ]
New Home Advertising (Newspaper, Site Brochure) 3	[ ]
Financial Institution 4	[ ]
Other (list) _____ 5	[ ]

27. Have you used PG&E rebate coupons in the purchase of any of the following:

27A. Natural gas clothes dryer	1. Yes 2. No	[ ] [X]
27B. Energy efficient clothes washer	1. Yes 2. No	[ ] [X]
27C. Energy efficient refrigerator	1. Yes 2. No	[ ] [X]

28. What is the highest education level for the head of the household:

Some high school 1	
High school graduate 2	
Some college/Junior college graduate 3	
College graduate 4	X
Graduate degree 5	

29. Approximate household income category:

Under $25,000 1	
$25,000-$49,999 2	
$50,000-$74,999 3	X
$75,000-$99,999 4	
$100,000-$149,999 5	
$150,000 or more 6	

30. Have you heard of the Energy Star New Homes Program that is being provided through the U. S. Environmental Protection Agency?

1. Yes	
2. No	X

31. IF YES: From what source did you learn about the different levels of energy efficiency in new homes?

Realtor 1	
New Home Advertising (Newspaper, Site Brochure) 2	
Financial Institution 3	
Other (list) _____ 4	

32. IF YES: Please describe what you know about this program:

_____

_____

_____

_____

END OF SURVEY, THANK YOU FOR PARTICIPATING

Appendix V

A Qualitative Research Report on Homeowners' Reactions to the Home Energy Advisor

A Qualitative Research Report

on

Homeowners' Reactions

to

the Home Energy Advisor

Prepared for:

Eley and Associates

June 1, 1999

Table of Contents

Background and Objectives 4

Methodology 4

Cautionary Note 5

Conclusions and Recommendations 6

Findings 8

- Perceptions of Heavy Energy Demands 8
- Past & Future Energy Saving Measures 8
- How Homeowners Determine Who to Call For Energy Efficiency Projects 9
- How Homeowners Know Their Projects Will Result in Energy Efficiency 10
- Barriers to Energy Efficient Improvements 11
- Solicitations 12
- Switched Electricity Providers 12
- Reactions to Home Energy Advisor Concept 12

Reactions to Features 14

Responses to Energy Saving Questions 14

Utility Bill Input 15

List of Recommended Improvements 16

Competitive Provider Analysis 16

3-D Capability 17

3-D Interactive 18

Ranking of Features 18

How Homeowners Expect to Hear about the Home Energy Advisor 18

What Homeowners Would Like to See in the Home Energy Advisor 19

Appendix 20

Residential Discussion Guide 21

Recruitment Questionnaire 28

Concept and Feature Statements 30

Background and Objectives

In an effort to support the California Energy Commission's PIER program goals to reduce consumer energy demand, Eley and Associates has been requested to produce a Windows-based design and analysis software tool. Prior to finalizing the specifications of the software, Eley and Associates requested marketing research studies to obtain input from the two target markets for the software: residential homeowners and design professionals.

This report summarizes the findings from the residential homeowner portion of the marketing research. A separate, subsequent report will summarize the findings from the design professional interviews.

The present research was designed to explore the viewpoints and interests of residential homeowners regarding the software tool. Specifically, this study sought to achieve the following objectives:

Obtain feedback from residential California homeowners regarding their overall interest in the software tool concept.

Ascertain what they consider to be useful characteristics and features of the software.

Provide direction for the overall look and feel of the product's user interface.

Methodology

One focus group was held on the evening of May 10, 1999, in Novato, California. The group lasted approximately two (2) hours and was audio and video recorded.

The group comprised ten (10) residential homeowners, half of whom were men and half women. All of the research participants exhibited interest in energy conservation, and regularly use a computer at work or at home and personally use the Internet. In addition, all group members stated they would be willing to download a software program from the Internet.

Participants' homes covered a range of styles including: a new single-story family home, ranch-style dwellings, older two- and three-story homes, and a mobile home.

The actual screening questionnaire used to recruit the participants appears in the Appendix of this report.

Cautionary Note

The focus group findings set forth in this report are qualitative in nature and therefore should be viewed as directional. The findings are not meant to be statistically projectable; they provide in-depth investigation and insight into the views and feelings of a small number of target users.

Conclusions and Recommendations

The Home Energy Advisor's appeal for homeowners derives from its ability to provide personalized and unbiased responses to their questions and to give them a platform to test the effectiveness of various energy saving measures.

Because homeowners' primary reason for implementing energy efficient measures is to save money on utilities, it is recommended that the program offer the capability to perform payback analysis. In addition, the software program would benefit from the inclusion of the following features discussed in this research study: Utility Bill Input, Responses to Energy Saving Questions, List Of Recommended Improvements, and Competitive Provider Analysis.

The software should be designed for two distinct types of users:

1) **Low Involvement Users** who seek a simple program for their infrequent project-related use of the software.

2) **High Involvement Users** who prefer an in-depth analytic software program for project-related use and for ongoing in-depth analysis of their energy usage.

Consideration should be given to designing the software for use on a web site. Homeowners in this research repeatedly expressed interest in having the functionality provided by the Home Energy Advisor available on-line. They are hesitant, however, to download it as a software program. Group members view a web site as an ideal platform for energy efficiency input and information.

Additionally, they would like to see a web site that offers numerous links to other energy efficiency related sites.

Respondents' second choice is to have the Home Energy Advisor available on a CD-ROM. Homeowners stated they'd expect it to be available by mail or distributed through retail building supply outlets, such as Home Depot.

For the residential user, the software does not need to have 3-D or 3-D Interactive capabilities. Homeowners are willing to use the program without these features. For

some, the 3-D capabilities adversely affect their interest in the program -- in fact, they scare them away. Incorporation of a mechanism to confirm users' input, however, is warranted.

Findings

Perceptions of Heavy Energy Demands

Asked to identify "the big energy users" in their households, homeowners mentioned both occupants and specific appliances. The following summarizes their responses:

Teenage daughters
Small Children
Elderly parents
Occupants who do not turn off lights
Water heater
Heater
Washer and dryer
Swamp cooler

It is interesting to note that, despite homeowners' high awareness of the energy saving qualities of double pane windows and insulation, individuals without these items in their homes did not name them as major energy users.

Past & Future Energy Saving Measures

Most of the research participants reported having made energy saving improvements in their homes. One person reported that a change in residence was motivated in part by a desire to have a more energy efficient home. Other participants reported that energy efficiency was a consideration when they purchased their homes, although for most it did not appear to have been the deciding factor.

The measures respondents identified having undertaken to increase the energy efficiency of their homes included:

Time of use meters
Double pane windows
Low E windows
Programmable thermostats
Wall insulation
Ceiling insulation
Ceiling fans
New HVAC systems
New heater
New air conditioner

Group members reported the following plans to promote further energy savings in their homes:

Encourage occupants to turn off lights
Replace single pane windows with low-e and/or double pane windows
Increase insulation in roof
Replace air filters
Insulate water heater

In general, group members' motivation and focus for increasing the energy efficiency of their households is to reduce costs. Their interest in decreasing energy consumption for environmental or "pro-green" reasons is secondary, at best.

How Homeowners Determine Who to Call For Energy Efficiency Projects

Overall, research participants do not know who to call for energy related projects. Reportedly, residential homeowners' current mode of operation includes asking for multiple bids or proposals. They seem to gain confidence and peace of mind by calling three or four companies to bid on projects. Names of individuals or companies to call are obtained through the Yellow Pages and/or by word of mouth.

Homeowners give most consideration to the lowest bids or those that are in line with

the others. Lacking any objective standards for comparison, these consumers appear to make "relative" comparisons and base their final decisions on their

One group member, a bookkeeper for a construction firm, stressed the importance of hiring a licensed contractor and suggested using the Builders Exchange as a resource for locating building professionals. Another participant suggested that potential firms can be screened through inquiries to supply houses as to whether or not specific contractors pay their bills on time.

By and large, groups members said, they stay away from companies that employ direct mail or telephone solicitation. Homeowners do not trust these companies with their energy efficiency projects.

How Homeowners Know Their Projects Will Result in Energy Efficiency

Homeowners reported it is simply "*common knowledge*" that certain projects will save energy. They cite repeated exposure to messages correlating specific measures with increased energy efficiency. The use of such items as insulation, ceiling fans, double pane windows, and programmable thermostats, all fall into this classification.

> *"Some of this you just know because they keep beating it into our heads."*

Some homeowners reported seeing an immediate reduction in energy costs following the installation of energy saving products, and others noticed qualitative differences in their homes.

> *"You can feel it."*

> *"I noticed a 50% improvement with a change in windows."*

One person reported calculating the cost savings of a particular project over time -- the payback period -- to determine whether it would be cost effective in the long run. Others reported depending on the yellow stickers on major appliances to determine energy efficiency prior to the purchase of a major appliance.

Despite their best efforts, residential homeowners frequently remain uncertain as to whether their remodeling and/or appliance purchases will truly pay off.

> *"You don't really know [if it saves energy]. It is like buying a car, you don't know; you need to do what is practical and go with references."*

Barriers to Energy Efficient Improvements

Homeowners quickly identified lack of money as the major barrier to furthering their homes' energy efficiency. The inconvenience and "mess" of remodel/construction projects was also noted as a major barrier.

Lack of knowledge coupled with insufficient information also contributes to homeowners' hesitation to implement energy saving improvements. They do not know where to start, so they put it off.

> *"The barrier for me was I had no knowledge of what I'd save and having to deal with it [the construction]."*

> *"People are not quite sure where to start. . . . They are scared to plunge*

Some group members felt low awareness of the cost savings afforded by specific changes is a barrier, as well as the absence of a specific reason or incentive.

> *"You need something to trigger it. I walked in and it was real hot, so I had a guy come out. If nothing gives you a signal . . . you are not apt to make any changes."*

Although not a barrier, one person mentioned postponing the upgrade of the insulation in his home in order to take advantage of a PG&E rebate program.

Solicitations

Group members reported they are frequent recipients of direct mail and telemarketing calls for services purporting to increase home energy efficiency. Most of the solicitations they receive are for siding, roofing, air conditioning, windows, heaters, and general home improvements.

By and large, homeowners stated, they do not respond to these solicitations because they do not trust companies utilizing these marketing techniques.

Switched Electricity Provider

One group member reported having recently switched to Green Mountain for electricity in his new home. He was uncertain whether the changeover had actually taken place since his bills still came from PG&E. He stated he was willing to pay a little extra for electricity that required less coal and oil. He felt it "was the noble thing to do." He also reported receiving bonus miles for United Airline's frequent flyer program for making the change. He felt this offer contributed to his decision to switch.

Other group members appeared somewhat unaware of alternative electricity providers and/or had not given the issue much serious thought.

Reactions to Home Energy Advisor Concept

Upon first learning of the Home Energy Advisor software, group members wanted to know who was offering it and what it would cost. They were delighted to learn that the California Energy Commission was authorizing the software and there would be no out-of-pocket costs to get it.

Group members regarded the software as a web site. They felt its functionality and their anticipated infrequent use of it would make it more suitable as a web site than stand alone software.

Although all of the participants stated they were willing to download software from the Internet, they overwhelmingly preferred to access the Home Energy Advisor via a web

site or on CD-ROM. Many homeowners admitted disliking lengthy and time-consuming downloads. They did not feel their projected usage of the software would warrant the time it would take to download it.

Group members agreed that they'd like to see the software available on a CD-ROM or for use at retail outlets, including hardware stores or other building supply outlets, such as The Home Depot.

> *"I pretty much run my life by computers. Give me the program . . . I will use it."*

> *"If there was a web site with all this information, I'd go to it; but I'd*

In general, most of the group members felt the Home Energy Advisor would be useful.

> *"[The software] could be really helpful in deciding what area of your home to make energy efficient when you are intimidated by a lack of knowledge."*

> *"It could be very helpful in making the decision to purchase energy*

Most group members agreed the software would need to be simple to use in order to be of value. Some group members, however, exhibited an interest in delving further into the program and using it to track their usage patterns over time.

> *"It would probably be a one-time use unless you are going to track your usage."*

Some group members compared the Home Energy Advisor to PG&E's energy assessment program. They concluded that the Home Energy Advisor offers more, since it allows users to test and compare various energy reduction plans.

Reactions to Features

Responses to Energy Saving Questions

Most of the group members stated they would expect the program to have this capability.

> *"Exactly what I expected the program would do."*

Some felt this feature afforded a "fun" way to get answers to their energy saving questions and responses to their ideas.

> *"You could use it if you had something in mind you wanted to do. You could run it through to see if it made sense."*

> *"I would be able to play with different ideas*

> *"It is like playing with ideas, like how would the house look in different*

Group members noted that it would be important for the program to take into consideration regional variables, such as weather, cost of construction, cost of building materials, and so forth.

One person noted that this feature of the software matched his view of its potential as a web site, in that his *"five second attention span"* would be satisfied via quick answers to his questions.

> *"If I saw something like this, it would get my attention. It is a good idea to pull me into the program."*

Most of the research participants felt this feature would provide *"good general information*." They felt it could potentially offer a variety of applications for the many household remodeling alternatives available to them as homeowners.

> *"[This feature] allows for more mindless fun investigation that may stimulate thoughtful follow through."*

Others felt this feature would serve as an adjunct to other resources they'd use to make decisions related to energy efficiency.

> *"This would be useful for project decision making."*

Utility Bill Input

Most of the research participants liked this feature. They assumed the software would serve them better if they were able to input their personal household data.

> *"I like this idea of being able to enter your own personal bills. . . . I can put in my data and get back information that is pertinent to my situation."*

> *"It would be nice to understand a little better the areas where I can save some money."*

> *"If you had confidence in this, you'd view it as an additional tool to take advantage of. It would give you interesting guidelines."*

As with the Energy Question feature, most group members expected the software to offer a feature of this type. They felt it to be essential in order for the program to be useful.

Some research participants believed it would be necessary to track their energy usage over a longer period then the one year suggested. They felt the additional information would enable them to more readily see patterns in their usage, which could perhaps assist them in identifying additional ways to save energy and money.

> *"This quantity of information does not put me on overload. The information is multi-use and provides greater depth and personalization."*

Most of the research participants stated they would not object to having to input their utility bill data. A few homeowners were unwilling to enter their personal data into a web site, but not into a computer program.

A few homeowners had no interest in spending the time required to input their data and/or did not feel the output would be worth the effort.

"I don't believe it would be personalized enough to be of any benefit to

One person, who stated that he does not presently understand his utility bills, hoped the feature might enable him to do so.

List of Recommended Improvements

This feature was viewed as *"good general information."* Most group members envisioned having access to this feature via a web site.

"I'd read it, but I don't know if it is a computer program."

"I would be able to think outside of my own box. It gives me information on things I've never even thought about."

Most group members felt that this information would be available via other sources, but noted there would be a benefit to having a centralized resource for energy saving related materials.

Competitive Provider Analysis

Members' skepticism on the subject of changing to alternative electric companies indicates that this feature is a bit ahead of its time. At present, it is a notion with which they are unfamiliar and, as a result, they expressed uncertainty about this aspect of the software.

"I am concerned about this feature".

"Who do I call if there is a power outage?"

"I get nervous when they are talking about green power."

A few of the research participants associated this feature with the need for competitive information in the long distance telephone or travel industries.

"It would be nice if they sent an email saying that rates have dropped for this provider; then you can check it out. It would be nice to have it handed to you."

One person felt this feature reminded him of the need to be assured there is no bias to the information he would be given by this software or web site.

3-D Capability

Many of the group members felt that having 3-D Capability in the software would make it more difficult to use and would require more time than they are willing to spend on learning such a program. Others were unclear what benefit 3-D capability would provide.

"Sounds like fun, but I don't see the purpose of it."

"There needs to be a serious benefit to justify your time putting in all

"It may scare people off, since it is not simple [to use]."

"If you have a simple question you may get scared away."

Some group members felt the 3-D Capability would add credibility to the process. Others felt it would be good for building a new house.

A portion of the participants reasoned that a visual confirmation of their input would be good, since the program's output would be based upon the accuracy of the user's data.

"May make a difference in terms of getting the right information."

For some, the 3-D capability would offer entertainment value. Others felt it may make the program "over featured" and too complicated.

3-D Interactive

The 3-D interactive feature was similarly held to be overkill, that is, an unnecessary complication of the program. A few respondents, however, felt this capability would make the program easy to use and "fun."

Ranking of Features

Group members ranked the six features in terms of their overall appeal.

Feature	Average Ranking (1-6)
Utility Bill Input	2.6
Responses to Energy Saving Questions	3.1
List of Recommended Improvements	3.2
Competitive Provider Analysis	3.3
3-D Capability	4.4
3-D Interaction	4.6

How Homeowners Expect to Hear about the Home Energy Advisor

Overall, group members felt they would learn about this software through the newsletter that comes with their PG&E bill, via an Internet search engine or Internet link, or at a retail building supply establishment, such as Home Depot.

What Homeowners Would Like to See in the Home Energy Advisor

Group members offered the following suggestions for the Home Energy Advisor software program and/or web site.

In-depth analysis of past usage data:

Highlight irregular patterns

Suggest improvements

Features such as available in 3D Home software

Automatic hookup to PG&E usage data (to eliminate the need for homeowners to input)

Usage data correlated to past weather patterns

Rebate offers from PG&E

Subscribed message service to alert consumers to available rebates, etc.

Payback analysis capability

Web-based links and references to books & energy savings information

Appendix

RESIDENTIAL
DISCUSSION GUIDE

INTRODUCTION (4 - 5 minutes)

The moderator welcomes the research participants and outlines the format for the evening's discussion.

- Ground rules and purpose

WARM UP AND BACKGROUND (15 - 20 minutes)

Everyone in the group introduces themselves by supplying the following information.

- Name
- Where live?
- Describe dwelling/residence
- When did you purchase your current dwelling?
- What are your average utility bills? --- Spring/Summer & Fall/Winter
- What % is for heating? For cooling?
- On a scale of 1 to 10 (1 low; 10 high) How energy efficient would you say you home is?
- What are the “big energy users” in your household?

ENERGY EFFICIENCY (10 - 15 minutes)

(Group discussion begins. Further investigation of issues raised in the Warm Up and Background.)

- *Let's talk some more about energy efficiency of your homes ….*

- What sort of "*things*" have you done to increase energy efficiency of your household? LIST

  Probe:
  What else?

- What do you plan to do or do you wish you could do to enhance the energy efficiency of your household? LIST

  Probe:
  What else?

- How did you know what to do/ who to hire?

  Probe:
  Where get your information?

- How do you know doing _____ increased/will increase the energy efficiency in your household?

  Probe:
  How else?
  Determinants (consumers' perspective)

- How do you/will you know your efforts have increased the energy efficiency in your household?

  Probe:
  How else?
  Determinants (consumers' perspective)

- Have you estimated the actual or project cost/dollar $ savings? If so, how?

  Probe:
  How else?
  Is it important to know? Why/why not?

- Did energy efficiency play a role in your original purchase decision (of your household)?

  Probe:
  In what way?

BARRIERS (5 –8 minutes)

- What barriers to improving your household's energy efficiency do you feel you face as a homeowner? LIST

  Probe:
  What else?
  Why?

PAST OFFERS (7 - 10 minutes)

- Have you been approached by companies promising energy efficiency?

  Probe:
  Describe

- How do you/have you evaluated these offers?

  Probe:
  How else?

- Have you ever switched electricity providers?

  Probe:
  Describe

- Have you ever thought about switching electricity providers?

  Probe:
  Why/why not?

- Have you ever switched your long distance phone provider in the past 10 years?

Probe:

Why/why not?

REACTIONS TO PRODUCT CONCEPT (8-12 minutes)

- *I am passing out a description of a computer program for homeowners. Before we talk about it, please makes some notes about how what you think about this idea, including what you like about it, what you do not like about it, how you envision using it, etc. If you have any questions about it, write those down also before we talk about it as a group.*

- What are you thoughts about this?

Probe:

Likes
Dislikes
Anything Confusing
Questions

- How do you feel about ..... ?

Probe:

Specifics: to be determined

- What is this computer program like?

Probe:

Why do you say that?

- What would it take the place of?

Probe:

What else?

- How does it compare to _____ (what it replaces)?

Probe:

Advantages
Disadvantages

REACTIONS TO FEATURES (20 – 30 minutes)

- *Thinking of this new computer program, I was wondering about how you feel about .....*

(PASS OUT FEATURES ONE AT A TIME AND ASK)

- What would be good about this feature of the computer program?

Probe:

What else?

- What would not be good about this feature of the computer program?

Probe:

Anything else?

- How does it compare to the present way in which you evaluate _____ (function)?

Probe:

Tell me more.

- Could you see yourself using this?

Probe:

Why/why not?

RANKING OF FEATURES (5 – 8 minutes)

- Please rank the features in terms of their appeal to you personally. The one which is the most appealing on top and least appealing on bottom.

(Moderator will come to the observation room for list of additional questions and/or probes)

- What is on top for you?

  Probe:
  Why?

- What is on bottom for you?

  Probe:
  Why?

OVERALL REACTIONS TO PRODUCT CONCEPT (3 – 5 minutes)

- Thinking back over this idea we have been talking about this evening, do you feel people will use it?

  Probe:
  Why/Why not?

- Would you personally use it?

  Probe:
  Why/Why not?

- Would you be willing to download it from the Internet?

  Probe:
  Why/Why not?
  Where do you feel you'd find it?

WRAP UP (5 - 7 minutes)

- Overall, thinking about the experience you had here tonight, the things we discussed and the things you saw; what impressed you the most?

Name _____ Telephone _____

Address _____ Interviewer _____

VERY IMPORTANT: AVOID RECRUITING ANYONE WHO IS NOT OBVIOUSLY FLUENT IN ENGLISH.

CHECK GENDER: (Attempt to get a mix) [ ] MALE [ ] FEMALE

1. Do you own or rent your primary residence?
   [ ] Rent (TERMINATE) [ ] Own (CONTINUE)

2. Is it a ...? [ ] Condominium (TERMINATE)
   [ ] Townhouse (TERMINATE) [ ] Single Family Dwelling (CONTINUE)

3. Does it have central air conditioning? and do you use it in the summer months?
   [ ] No (TERMINATE) [ ] Yes (CONTINUE)

4. Do you use the central air conditioning in the summer months?
   [ ] No (TERMINATE) [ ] Yes (CONTINUE)

5. Do you use a computer regularly at work or home?
   [ ] No (TERMINATE) [ ] Yes (CONTINUE)

6. Do you personally have access to Internet at home or work?
   [ ] No (TERMINATE) [ ] Yes (CONTINUE)

7. Do you personally use the Internet?
   [ ] No (TERMINATE) [ ] Yes (CONTINUE)

8. How likely would you be to download a a software program, you were interested in, from the Internet [assuming downloading off the Internet was the only way to get it]?
   [ ]Very Likely (CONTINUE) [ ] Likely (CONTINUE)
   [ ]Unlikely (TERMINATE) [ ]Very Unlikely (TERMINTE)

9. Do you or any member of your household work .....?(READ LIST-TERMINATE IF YES FOR ANY OF THE ITEMS LISTED)

Yes	No	
[ ]	[ ]	in marketing research
[ ]	[ ]	for utility company providing gas and/or electricity
[ ]	[ ]	in the building or "*energy savings"* industries

10. What is your occupation? Who do you work for? (VERIFY MEETS INDUSTRY SCREEN Q. 9)

    _____

11. The following statements are a wide variety of attitudes toward energy saving and energy in general. I'd like you to tell me how strongly you agree or disagree with each statement using the following scale: Strongly Agree, Somewhat Agree, Slightly Agree, Slightly Disagree, Somewhat Disagree, or Strongly disagree. [TO QUALIFY MUST BE SOMEWHAT OR STRONGLY AGREE TO STATEMENTS: A. B, D AND SOMEWHAT OR STRONGLY DISAGREE WITH STATEMENTS C AND E]

	St. Ag.	So. Ag.	Sl. Ag.	Sl. Dis.	So. Dis.	St. Dis.
a. I would like my house to be more energy efficient.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
b. Saving the worlds resources is important to me.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
c. Saving energy is a topic I'm really not interested in.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
d. I truly value saving energy.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
e. I have and plan to do nothing or very little to reduce my household's energy requirements.	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Concept and Feature Statements

The Home Energy Advisor

The Home Energy Advisor is a computer program that helps homeowners to evaluate "energy efficiency" types of home improvements.

The program asks users questions, such as: house size, shape, age, location, number of residents and types of appliances. The program then calculates approximately how much energy is typically used by the house and by each appliance such as refrigerator, air conditioner, heating system, clothes washer/dryer, etc. The program enables users to test hypothetical home improvements, such as new windows, and see the potential impact on their utility bill.

Responses to Energy Saving Questions

The Home Energy Advisor enables users to simply ask questions regarding energy savings and receive a response. The computer software program takes into consideration users' specific input regarding their households when providing a response.

For example a user can ask a question, such as: "How much energy would I save if I planted a big shade tree on the west side of my house?" The program responds with an answer tailored to the user's situation.

Utility Bill Input

The Home Energy Advisor's accuracy can be improved by allowing for utility bill input. Users are able to input specific information from their actual utility bills.

For example: a user could enter data from their last few utility bills ---- up to a full 12 months of utility bill input. The software program is then "calibrated" to reflect the

The utility bill input allows the program more accurately perform all its functions, such as: breaking down a bill into end-uses; and calculating the savings from potential home improvements, etc.

List of Recommended Improvements

The Home Energy Advisor will automatically produce a list of recommended home improvements that are cost-effective for the user's current energy usage situation.

In addition to describing the cost-effectiveness of certain improvements, the program will also describe some of the *non-economic* benefits of the improvements, such as: reduces draftiness, improves comfort, quieter operation, lasts longer, etc.

For example: the program could describe the advantages and disadvantages of installing new wood windows versus new aluminum windows.

Competitive Provider Analysis

In the future consumers will be able to select their electricity provider not unlike they choose long distance telephone service providers today.

The Home Energy Advisor will provide detailed information on alternative electricity providers including their latest offers and costs.

The program will analyze alternative electricity providers based upon information provided by the user regarding their current households. The program provides users with the "best deal" for their particular situation.

In addition, the program will maintain information on how the electricity (provided by the *"green power"* electricity alternatives) is produced.

The program can be directed to analyze homeowners' situations by which electricity alternative provides the best "value" in terms of pollution reduction. It will detail exactly how much pollution (in terms of units like pounds of carbon dioxide, etc.) one's house produces in a given year with a given electricity provider.

3-D Capability

The Home Energy Advisor shows users a simple 3-D model of their homes to verify their input. This feature allows users to edit the 3-D model (using their mouse) to improve the program's accuracy. For example: the user could enlarge a room or rotate the building.

This 3-D feature also allows the user to use this graphic interface to "build" the model of their house and edit it simply by "dragging and dropping".

For example: a user could drag and drop different shaped rooms onto a foundation; then drag and drop the windows and doors onto walls, etc.; and then drag and drop the appliances, lights, TVs, etc. The program also enables the user to drag and drop the number adults and children in the house.

3-D Interactive

The Home Energy Advisor allows users to fine tune their input by simply double clicking on the 3-D model of their homes.

For example: The user can click on a window and answer the question “Is it single or double pane glass?” or click on a refrigerator and specify how big and how old it is.

The user can also double click on the graphical representations of people in their household and specify their habits, such as: if they work at home, if they are good about turning off lights, or setting back the thermostat at night, etc.

Appendix VI

Residential Building Professionals' Reactions to the Home Energy Advisor

Residential Building Professionals' Reactions to the Home Energy Advisor

Prepared for:

Eley and Associates

July 6, 1999

Table of Contents

Introduction

Background and Objectives 3

Methodology 4

Cautionary Note 6

Conclusions and Recommendations 7

Findings

Appeal of Energy Savings 10

Reactions to the Software Concept Overall 11

Projected Use of the Software 11

The Software as an Active Design Tool 11

The Software as a Sales Tool 12

The Software and Title 24 Requirements 14

The Software as an Educational Tool 15

Potential Features of the Software 16

Overall 16

AutoCAD Compatible 16

Ease of Use 17

Up to Date 18

Output 18

Additional Considerations 19

Projected Need of Technical Support 19

Branding 20

Cost Expectations 21

Suggestions on How to Market the Software 22

Lack of Appeal of the Software 22

Appendix ` 24

INTRODUCTION

Background and Objectives

In an effort to support the goal of the California Energy Commission's PIER program to reduce the consumer energy demand, Eley and Associates has been requested to produce a Windows-based design and analysis software tool. Prior to finalizing the specifications of the software, Eley and Associates requested marketing research studies to obtain input from the two target markets for the software: residential homeowners and residential building industry professionals. This report focuses on the latter target market. An earlier report summarized the findings from the research study among homeowners.

This portion of the marketing research was designed to thoroughly examine the needs and interests of building professionals and to explore their reactions to the concept of the professional version of the Home Energy Advisor software. [A concept statement used in this study appears in the appendix of this report.] Specifically, this study sought to achieve the following objectives

- To obtain feedback from residential building professionals regarding their overall interest in the professional version of the software

- To determine how professionals plan to use software in their design and/or sales process

- To ascertain which characteristics of the Home Energy Advisor software professionals consider to be useful

- To create basic guidelines for the overall look and feel of the software's user interface.

Methodology

Six (6) in-depth one-on-one interviews were conducted among California based residential building professionals. The interviews lasted between one hour and one hour and fifteen minutes and were conducted during June, 1999.

The six interviews were divided across different disciplines and reflected the following breakdown.

Two (2) **Architects**. One professional who works for a medium size firm that designs for tract builders and one who works for a small office that does custom and semi-custom houses for small developers.

Two (2) **Home builders.** One professional from a large firm who is in charge of working with the architect and participates in making design decisions and one professional who runs an

independent company, building 1 to 4 homes a year with the help of a small staff.

One (1) **Window manufacturer.** One professional who works for a company that is involved in the new construction market.

One (1) **Energy service provider.** One professional who works for a company that offers “green” energy.

All of the individuals participating in the research study are willing to test the prototype version of the software. A full listing of the participants in this research study appears in the appendix of this report.

Cautionary Note

The research findings set forth in this report are qualitative in nature and therefore should be viewed as directional. The findings are not meant to be statistically projectable; they provide in-depth investigation and insight into the views and feelings of a small number of potential users.

CONCLUSIONS AND RECOMMENDATIONS

The professional version of the Home Energy Advisors clearly holds appeal among building professionals. The extent of its appeal rests in the software's ability to provide ease of use, including a limited time requirement for entering project specific information.

Architects appear to be the key market segment, exhibiting the greatest potential for benefiting from the computer software. Architects easily envision using the software as an active design tool during the schematic design phase. Critical to the software's success among this segment is its ability to be compatible with AutoCAD, which dominates the architectural software design marketplace. As a result, development of the software as an AutoCAD plug-in holds the widest appeal. Alternatively, designing the software to maximize the use of data already entered into AutoCAD would be beneficial.

A software tool design requiring architects to input more than 2 hours of data (outside of AutoCAD) will most likely not be used.

The secondary professional market for the Home Energy Advisor is among subdivision developers who would be able to use the software as a sales tool. Smaller, local subdivision developers foresee utilizing the software in conjunction with their architect as a way to "advertise" their homes. This smaller subdivision

builder is willing to spend time and money on the software as a means of differentiating their homes from those of a national builder.

The larger, national subdivision developers, on the other hand, are unwilling to spend the time to input the necessary data themselves and are also unwilling to spend the money to have their architects do so. They feel the software's potential lies in its use as a tool for selling options such as windows, insulation, and/or HVAC. They expect to be given the software from energy related equipment manufacturers in a preprogrammed version. They need a summarized, user-friendly version of the software for use by on-site sales personnel.

Energy related product manufacturers regularly have access to architectural designs and might be willing to do the necessary input in order to convince customers of the cost and energy saving benefits of their wares. In addition to providing software for use by large developers, the energy related manufacturer may use the software when making sales calls to architectural firms.

Overall, potential users expect the software to provide: accurate estimates of energy use, annual energy costs and simple payback.

Branding the software from the California Energy Commission or in conjunction with the commission should give the software the needed credibility and enhance its rate of adoption.

At this time the software does not hold appeal in the energy service provider segment of the market. Marketing to this segment should be delayed until they become more cost-competitive.

FINDINGS

The Appeal of Energy Savings

The individuals interviewed in this research study feel that energy savings play a major role in their professions primarily from a regulatory standpoint. Most building professionals feel restricted by the requirements and would welcome alternative solutions to dealing with compliance issues.

> *"Energy is a big thing. It is being talked about more and more [by other professionals]. We get pushed as builders and don't have choices anymore."*
>
> *"In Marin we have five climate zones and a lot of regulations, zone parameters and high construction costs and long approval times."*

In addition, the research participants felt that, by and large, consumers are aware of energy savings issues. They feel consumers are "educated early on" regarding the cost of energy and the advantages of energy saving components and designs. One builder stated that during the resale of one of the houses she had built, the realtor stressed its' high grade of insulation. This energy saving feature contributed positively to the sale of the house.

Reactions to the Software Concept Overall

The concept of the software was appealing to the architects and builders involved in the design and sales of subdivision and custom homes and to the window manufacturer participating in this research study.

Projected Usage of the Software

The Software as an Active Design Tool

The architects participating in this research study considered the software concept to be a "good idea." They liked the notion of being able to allow for energy related issues early in the design phase.

> *"Being able to do calculations at early stage would be a*

> *"With this [energy related] input sooner rather than later, the house may begin to build itself."*

> *"I see being able to use it as an active design tool versus getting the building to pass requirements."*

The architects envisioned being able to use the software during the schematic phase. They expect the program to tell them how they can make a schematic design more energy efficient.

"To be able to refer to it early on and be able to let's say, change orientation of the structure would be effective."

The architects thought the program would enable them to combine different types of material and design elements in an effort to *"test out"* various energy related trade-off scenarios. This capability was especially attractive to them.

The Software as a Sales Tool

The builders and the window manufacturer felt they would be able to use the software as a sales or marketing tool.

The builders felt that, depending upon the client, the software could potentially serve as a marketing tool for subdivisions as well as for custom homes, depending upon the client.

"As a small subdivision builder, I was always looking for ways to set myself apart from the big national firms. I wanted to be able to compete with them. Perhaps this would be a way to get a nice marketing edge."

"It would be interesting to people buying in subdivisions. The very accounting minded and even the very blue collar are very concerned about energy … Buyers are no dummies. Having [information from program] would be a nice angle for selling."

One large subdivision builder felt the program could be used in their on-site sales locations where they sell homes by showing model homes and lot sites to prospective buyers. The builder feels there is potential to use the software as a tool to sell upgrades or higher costing options, such as: more energy efficient windows, higher grade insulation, more effective HVAC systems, etc.

> *" Some people are just financially squeezing into these homes. Showing them how upgrades would reduce their energy costs may be of help."*

In terms of custom homes, the interests and concerns of the client are key. One builder felt that the consumer building a custom home has the financial capability to overlook energy saving issues. Another builder and both architects disagreed, believing that some clients specifically request energy saving as a design consideration and many others show an interest when it is brought to their attention.

> *" In custom homes the heating and cooling issues are not a major issue. The client usually has the means to pay. Only if he is energy conscious would it become an issue."*
>
> *"It all depends on the client and what is important to them. One may be very energy conscious; another very cost concerned. Some paybacks are just not enough, like spending $2,000 to save $80 a year."*
>
> *"Clients do not say, 'I want an energy efficient house.' They are more reactive and say things like, 'my current house is bright and hot and I don't want that in my new house.'"*

One architect thought he may be able to use the software as a billable service to his clients.

> *"As an architect I could use is the software as a selling tool. I'd be able to give clients more choices and add service. I could run an energy audit of two to three schemes and have the initial cost outlay and energy cost savings. I'd charge $200 to $500 for it. I would not give it away for free."*

In addition, the software was considered to be appropriate for use in the sale of windows. The window manufacturer participating in this research study felt the software might be useful in his company's sales force, which calls upon architects. Although architects usually specify many of their firm's windows, there are times when window manufacturers are given the opportunity to assist the architect with this process. He felt the sales people could perform trade-off analysis of window alternatives and other energy related specifications on laptop computers in the architect's office.

The Software and Title 24 Requirements

The architects participating in this research expressed interest in having the software reduce their need for Title 24 energy consultants. This is because they plan to use the software as a way to provide consultants with a design that is more likely to pass current standards.

One architect dreamed of a day when his firm's need for energy consultants would be eliminated altogether by his use of the new software. At the same time, he stressed that the software would need to be easy to use.

> *"It would be a big positive if we could do Title 24's in house.*

The Software as an Educational Tool

The software was also considered to be useful in educating consumers, especially those building custom homes or selecting options in tract home developments, regarding energy issues. Research participants agreed that decisions on the type of windows, doors, and appliances used in a home are frequently made by the end user.

> *The owners are involved yet the don't understand the*

> *"Clients do not understand the difference [between various options]; this information would help them make a decision. For example they could be given the life cycle heating costs of the various HVAC units."*

Potential Features of the Software

Overall

As a whole, interested research participants stated that they should be able to input the particulars once and then *"play around"* with alternative scenarios. They stated that perhaps the software should have the capability to perform full and short analytical processes. The full offering a more precise analysis and the short providing a more simple analysis.

> *"…for example, after defaults are set . . . like climate, location, materials, and basic floor plan and so forth . . . I'd expect a design with a pull down window to perform an energy check and a compliant check."*

AutoCAD Compatible

Most of the participants stated that the software needs to be compatible with AutoCAD. They feel it needs to be easy to use and not time intensive. They want to be able to integrate all aspects of their design work. As a result, the interested interviewees envisioned the software as a plug-in to AutoCAD.

Ease of Use

The research participants stressed the need for the software to be easy to use. The design professionals felt the input time for a single design should be one to two hours.

> *"If it were easy to use I'd be interested. Otherwise, out. I am more consumed with design issues and that they pass design reviews. If this could help, I'd have one less thing to worry about. … I'd be willing to put in one hour of my time; otherwise I'd rather do design."*

The builders were less willing to spend time with the program. The subdivision builder stated that his sales staff are not highly computer literate and thereby the program should require only 5 to 10 minutes of input time.

> *"Many of our sales people are not into computers and would not be comfortable with something requiring a lot of input. Many of them only know to 'push here or push there,' to get what they need."*

Up to date

One architect stressed that the software needs to be up to date, meaning that it contains all of the materials available to design professionals in making houses energy efficient. In part he feels there is a need to maintain a web site where the

software can be easily be updated since new energy saving solutions are constantly being developed.

> *“It is a contemporary idea and needs to be up to date in terms of all the products & alternatives available.”*

Output

Everyone agreed the ideal output from the software program is Simple Payback. They feel it is an easy way to comprehend figures and is in line with how the consumers think. Target users assume this calculation will include accurate estimates of energy use and annual energy costs.

One of the architects thought the software’s ability to provide the time replacement of the building materials and their expected maintenance costs would be useful.

In addition, some of the participants mentioned the annual energy or operating costs of the various alternatives would be useful itself.

Additional Considerations

Other calculation features and considerations that research participants noted as wanting the software to include were: determination of solar angles, solar charting, solar gain for each room, building orientation, building massing, HVAC systems, window orientation and area, window construction, water heating systems, duct losses, venting, and heat retention.

Projected Need of Technical Support

Most of the research participants expect telephone support for the software. They want to be able to speak with someone Monday through Friday from 8:00 a. m. to 6:00 p. m. and on Saturday, perhaps for reduced hours.

"Something like this, you'd need a lot of technical support."

The ability to obtain email responses to ones queries was considered a good addition, but not a substitute for telephone support.

By and large the participants also expect there to be a web site to support the software. They envisioned using the site to keep abreast of the developments of

environmental products, which may impact their designs, and to upgrade or update their software.

> *“There should be no lag time of information.”*
>
> *“I could see using a web site to keep abreast of new program functions.”*

Branding

The majority of the research participants were comfortable with having the software endorsed or produced by or in conjunction with the California Energy Commission.

Most felt the California Energy Commission name in association with the software would serve as “a stamp of approval” which they feel is a major plus.

> *“It’d be great and add real believability.”*

The need for a third party endorsement of the software was of critical importance to builders of subdivisions.

> *"If not the California Energy Commission, then there is the need for an independent source to endorse it, especially when you are trying to sell a options for homes in a subdivision."*

The window manufacturer, however, harbors great disdain for the commission because of the commission's treatment of the aluminum window industry and as a result, was not in favor of associating the software with the commission.

Some participants noted that they would like the California Energy Commission to also advertise the software to the general public so that they would in turn benefit from their use of the software.

Cost Expectations

It was difficult for the research participants to estimate a price for the software based upon the concept statement. However, one architect felt that if the software could eliminate the need for a Title 24 Energy Consultant, he would expect the cost of one copy of the software to be around $300.

The subdivision builder felt that one of his suppliers, such as a HVAC company, would make the software available for his firm's use for free. He feels these firms

would ultimately benefit because homebuyers would be convinced by the software to make upgrades.

Suggestions on How to Market the Software

Research participants offered the following suggestions as avenues for marketing the software:

Through the National Association of Home Builders

Through the California Builders Show

Through the Western Builders Show – Building Industry Association

Providing it at Retail Stores Selling Windows

Lack of Appeal of the Software

The energy service provider did not see a use for the software in his business. He felt consumers do not need to know the particulars of the types of energy resources they purchase and that, as of now, his company does not offer any sort of cost advantage to compete with major utility alternatives.

> *"It's hard to believe that consumers would go to that level of detail. They just would want to know its renewable and there are no air emissions."*

The software was also considered less useful for builders of single spec homes.

“Single family homes built on spec are largely not driven by

Appendix

Summary of Research Participants

Thomas Hood

Architect

415-461-9490

Sole Proprietor in CA for 10 years

Involved In Custom Home Design and Single Family Homes On Spec.

Licensed As Architect Since 1975

Michael Suchocki

Architect

925-743-3374

The Dahlin Group
Involved With Large Residential Developments And Custom Homes

2 ½ Years As Licensed Architect

Rick Counihan

Energy Service Provider

415-439-5310

Green Mountain Energy Resources

19 Years In Energy Conservation Industry

Has Worked For Congress; State Of Mass.; City Of Claremont

Summary of Research Participants con't.

Alan Newman

Blazer Homes

916-773-3888

Vice President of Sales Blazer Homes

National Subdivision Developer

20 Years In Residential Home Development Business.

Cheryl Gibson

Von - Jac

916-652-4674

President

Past Small Subdivision Developer

Current Builder of 1 – 4 Custom Homes Per Year

Steve Reynolds

Blomberg Windows

916-428-8060

Project Manager

Works with Shop Drawings

AutoCAD since 1988

Concept Statement

A computer program for accurately estimating energy use in both existing and new residential buildings. An architect, builder or professional familiar with residential construction would be able to describe an existing house or design to the computer in one to two hours, either by referring to a set of plans or by doing a walk through audit. Once data is entered, the program would:

- Evaluate possible home improvements or design alternatives, such as windows, HVAC equipment, water heating equipment, better appliances, etc. Estimates of energy savings, cost and economic performance (e.g. return on investment) would be produced.

- Evaluate offerings from utilities and/or energy service providers and find the offering that would result in the least cost to the homeowner and/or have the least environmental impact.

- Provide detailed information and breakdowns of energy end uses such as heating, cooling, water heating, refrigerator, clothes washer/dryer, dishwasher, interior lighting, pools, spas, etc.

Interview Guide

Describe for me your role in the residential building field?

Probe: Further Details if warranted.

Could you envision using the program?

Probe: Why/why not?

How? Describe in detail.

What should the program take into consideration?

Probe: What else? Why?

What about? *Building massing (height, width, depth, bulk, etc.)? HVAC equipment/systems? Water heating equipment/systems? Duct losses? Building insulation? Window orientation and area? Window construction, e.g. double glass, low-e glass, tinted glass, frame type (vinyl, wood, metal), etc.?*

What program features appeal to you?

Probe: What else? Why?

What about: *Ability to accurately estimate energy use? Annual energy cost? Compliance with codes, standards and voluntary programs from utilities, EPA or others. Homes energy rating? Life cycle cost analysis? Calibration to utility bills? Comparison against average utility bills in their neighborhood.*

What output would you expect/find useful?

Probe: *Simple payback? Internal rate of return?*

How much time would they be willing to spend using the program?

Probe: Why do you say that? Explain in Detail.

What would you expect in terms of technical support?

Probe: Why?

In terms of branding of the software, how would you feel if it were branded from or in association with…. ? READ OPTIONS

Association with the California Energy Commission? U. S. Department of Energy? DOE-2?

How much would you be willing to pay for the software?

Probe: Why do you say that?

Would you be willing to test the program when it is available?

Appendix VII

Product Readiness Plan

HomeEnergy Software

Task 2.10.2
Final Product Readiness Plan

January 8, 2001

Prepared for:
California Energy Commission
John Easch, Contract Manager

Contract Number 500-98-025

142 Minna Street
San Francisco, California 94105
(415) 957 1977 Voice
(415) 957 1381 Fax
www.eley.com

Contents

Contents....1
Introduction....2
Critical Production Processes and Systems....2
Capacity Constraints....2
Hazardous or Non-recyclable Materials....2
Production and Distribution Costs....3
Web Download Costs....3
CD Distribution Costs....3
Software Upgrade and Improvement Costs....4
Technical Support Costs....4
Investment Threshold....4
Implementation Plan....4
Software Price....4
Download version....4
CD version....5

Introduction

HomeEnergy has two versions: the lite version and the professional version. The lite version is free while the professional version will include a license fee for unlocking all of the software features.

HomeEnergy is a software product and can be distributed either by web downloads or CD Mailings. Orders can be handled manually or through E-commerce.

This production readiness plan is written to address questions listed in Subtask 2.10.1 of the scope of work:

- Identification of critical production processes, equipment, facilities, manpower, and support systems that will be needed to produce a commercially viable product;
- Capacity constraints imposed by the design under consideration for internal manufacturing capabilities, as well as suppliers. The project manufacturing effort may include "proof of production processes";
- Identification of hazardous or non-recyclable materials.
- A projected "should cost" for the product in production at some expected rate;
- The expected investment threshold required to launch the commercial product;
- An implementation plan to ramp up to full production;

Since HomeEnergy is a software product, this plan is relatively simple. Production requires only a modest investment and production capacity can be rapidly increased according to demand. This report does not address marketing costs.

Critical Production Processes and Systems

The software production and distribution process requires:

- Computer and CD writing equipment
- Printing and packaging production equipment
- Order taking and tracking system
- Internet distribution equipment and software
- Package delivery system
- Technical support system

Each of these systems is widely available and the service markets are very competitive, ensuring reasonable costs. Therefore, none of them are expected to present barriers to production for HomeEnergy. Eley Associates currently distributes other software and these systems are already in place.

Capacity Constraints

There are no significant capacity constraints for foreseeable distribution volumes. CD production, internet distribution and package delivery volume can be increased easily. The only potential constraint is technical support capacity if distribution is very high.

Hazardous or Non-recyclable Materials.

No hazardous materials are directly involved in production or distribution.

CDs are likely to be non-recycable, but all packaging will be recyclable (and recycled) paper.

Production and Distribution Costs

This section includes predictions of costs at varying production volumes.

Web Download Costs

Web downloads are an increasingly popular form of software distribution. Web downloads can be set up as pages on the Eley Associates web site or as a separate web site. The following is an outline of procedures and costs necessary to provide HomeEnergy as a web download from the Eley Associates web site.

1. Web Development and Maintenance

Web development cost is about $4000, maintenance cost is about $500 to $1500 per month depending on traffic.

2. Web Space

HomeEnergy needs about 40 MB of storage space, which costs about $40 per month according to Pac Bell hosting rates.

3. Web Traffic

Web traffic of up 12 downloads per month would be included in the storage space cost. After the 12th download, additional downloads would cost $4 each per month. More cost effective, high volume, hosting packages are available if download distribution greatly exceeds 12 downloads per month This analysis assumes about $5 per download at low volume, $3 per download at medium volume (100 per month) and $1 per download at high volume (1000 per month).

4. Order Handling

A labor cost of about $10 per order will be involved with taking order information and generating registration codes for licensed users.

Production and Delivery Costs for Web Distribution

Downloads per month	Fixed Cost	Variable Cost (per unit)	Total Cost per month	Total Cost Per Unit
10	$500	$15	$650	$65.0
100	$1000	$13	$2,300	$23.0
1000	$1500	$11	$12,500	$12.5

CD Distribution Costs

The software can be produced on CDs and sent to people who prefer this medium. The procedures and costs will include,

1. Web Development

Web development costs about $3000, maintenance cost is about $500 per month.

2. Order Handling, CD burning and Shipping

A labor and delivery cost per CD will range from $20 for large volumes to about $40 per order at low volumes. These costs included order taking as well as burning, packaging, and shipping the HomeEnergy CD.

Production and Delivery Costs for CD Distribution

Downloads per month	Fixed Cost	Variable Cost (per unit)	Total Cost per month	Total Cost Per Unit
10	$500	$40	$900	$90.0
100	$750	$30	$3750	$37.5
1000	$1000	$20	$21,000	$21.0

Software Upgrade and Improvement Costs

An estimated 80 hours per year of software improvement will be needed to remove identified bugs and improve program performance.

Technical Support Costs

Support costs will range from $0 to about $150 per unit, with an expected average of about $15 per unit.

Investment Threshold

The investment required to setup production at commercial levels is relatively small, on the order of $10,000 for internet setup and packing development. Marketing required to reach high distribution will likely require more investment, but a marketing plan is not included in this report.

Implementation Plan

Implementation requires the following steps prior to distribution. Production levels can be increased quickly according to demand.

- Final software development
- Packaging design
- Packing production
- CD printing
- Website development
- User database development and order system setup
- Technical support process setup and training

Software Price

Final pricing is yet to be determined, but the following is a possible pricing scenario.

Download version

The professional version may be priced at $200 per license for web download (CD not mailed). The lite version download is free. The license fee includes one month tech support. Extra tech support cost is about $100 per license per year.

CD version

The professional CD version may be priced at $250 per license. The lite CD version may be offered at $30 for shipping and handling. The license fee may include one month tech support. Extra tech support cost is about $100 per license per year.